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ACCIDENTAL
EPISODE

ACCIDENTAL EPISODE MANUAL

prepared for
Environmental Protection Agency
Office of Air Programs
Research Triangle Park
North Carolina 27[illegible]

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This manual spells out in simple and direct language what the Air Pollution Control Agency can or ought to do during an event to help minimize its impact upon the people and economic life of the community. This manual includes a standard operating procedure developed from the cumulative experiences of public officials and the scientific and technical community from all parts of the country. Furthermore, it contains background on hazardous material, probabilities of occurrence, probable mechanisms and causes, prediction of danger and safety zones, and typical case histories. As currently viewed, the legitimate role of an APC agency in accidental episodes is that of support through its capabilities in the following areas: air quality surveillance; and estimate of hazard area. The manual is presented in two related but self-contained parts: Part I. Contingency Action Guide for Air Pollution Control Agencies; Part II. Contingency Action Guide for Local Communities.

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FOREWORD

Scarcely a week passes without news reports of another incident in which the escape of hazardous material into the atmosphere necessitates wholesale evacuation of people from their homes and places of business. In most cases there is a precedent traumatic or catastrophic event, such as a highway or railroad accident, a fire, a windstorm or other natural disaster. Sometimes, however, the cause lies with the breakdown of normal safeguards in factories, even in private dwellings. For whatever reason, the result is often a large-scale threat to life and property.

The hazardous substances are characterized by varying degrees of toxicity, flammability, and reactivity (tendency to combine chemically with other material, resulting in corrosion, explosion, or physiological irritation). Accidental episodes involving such material should be handled only by individuals and teams that are especially trained and equipped for the purpose.

Responsibility for action to protect the health and welfare of the community during such an event normally rests with the local department of public safety (police and fire), and in a more serious crisis, with the chief executive of the community and ultimately with the governor of the state. Many states and local communities have organized emergency response teams in accordance with contingency plans.* These teams usually include public health specialists and engineers to provide guidance on technical problems surrounding the event. More and more, Air Pollution

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* The word "contingency" is in common usage throughout the Environmental Protection Agency and elsewhere to denote an unforeseen or unexpected event, particularly one associated with undesired or harmful effects such as an accidental episode. A "contingency plan" is a formal, documented program to provide for readiness in advance of contingencies by assigning, defining and coordinating the responsive action of participating teams and individuals.

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Control (APC) Agency officials are sought out because advice on the nature and behavior of atmospheric contaminants and interactions seems like a logical extension of their background and responsibilities. An increasing number of APC officials in turn have looked to higher technical authority for guidance and support on these issues.

This

Many have expressed a need for a manual ~~that will~~ spell out in simple and direct language what the APC agency can or ought to do during an event to help minimize its impact upon the people and economic life of the community. This manual ~~would~~ include a standard operating procedure developed from the cumulative experiences of public officials and the scientific and technical community from all parts of the country. Furthermore, it ~~would~~ contain ~~important~~ background on hazardous material, probabilities of occurrence, probable mechanisms and causes, prediction of danger and safety zones, and typical case histories.

Manuals for contingency action have been produced by a number of organizations, and others are in preparation at this time. Disaster Plan Manuals have been prepared for every State in accordance with the Disaster Relief Act of 1970 (PL 91-606) and precedent legislation. Disaster Manuals and related documents have been developed by:

- Public Health Service
  (Health Services and Mental Health Adm., U. S.
  Department of Health, Education and Welfare)
- American National Red Cross
- Office of Civil Defense
- City or County Disaster and Civil Defense
  Offices (e.g., Los Angeles)

and others. These documents generally cover the entire spectrum of natural and man-made disasters, from earthquakes and floods to nuclear attacks. The attention given to chemical spills is necessarily limited.

In general, these documents provide planning guides and procedures that are common to all emergencies and leave further details on specific types of events to specialty teams and organizations. Their principal aim is to assist in establishing such organizations and making existing ones more effective. At the other extreme are Standard Operating Procedures for specialty teams such as those of the Chlorine Institute, the National Agricultural Chemists Association, and industrial Mutual Aid groups, which focus narrowly upon a specific family of chemicals or a limited geographical area.

In the main, existing manuals make no provision for formal participation of APC agencies on contingency teams, except when agency responsibilities include radiological monitoring. Certain APC agencies have themselves taken the initiative in developing a contingency organization in which they exercise a vital supporting role if not leadership itself. As currently viewed, the legitimate role of an APC agency in accidental episodes is that [illegible] support through its capabilities in the following areas:

1. Air quality surveillance; and
2. Estimate of hazard area.

As contingency response teams are presently constituted, no other members have responsibility for or access to both capabilities.

The manual herewith focuses upon the APC agency role in these areas. And yet, it is not intended for the exclusive use of these agencies; others like department of public safety, civil defense and disaster organizations, industries, common carriers, and mutual aid groups should find it applicable to their own activities. To these all, the manual may serve as a guide toward developing and implementing a contingency plan for effective action following an accidental release or spillage of airborne hazardous substances. Accordingly, the manual is presented in two related but self-contained parts:

Part I. Contingency Action Guide for Air Pollution Control Agencies
Part II. Contingency Action Guide for Local Communities.

1. INTRODUCTION

1.1 DEFINITION OF ACCIDENTAL EPISODE

An accidental air pollution episode is defined as an unexpected event during which contaminants are released into the air in amounts that are potentially hazardous to public health and welfare under circumstances which do not require a prolonged and widespread meteorological stagnation condition. It usually occurs when a relatively massive quantity of contaminant is released into the air and transported over inhabited areas. It is often the result of unawareness or unavoidable causes, through mechanisms such as:

a. Industrial process error
b. Plant equipment failure
c. Transport accident
d. Consumer error
e. Secondary effects of fire, flood, explosion, windstorm or other catastrophic events.

For the purposes of this work, events that do not affect the general public are excluded. These include accidents in the following activities.

a. Agriculture (e.g., field dusting)
b. Mining
c. Military activity

Also excluded are accidents that do not produce hazardous airborne contaminants.

Several factors which will differ in their relationship to an accidental episode in comparison with a natural episode are:

a. Time

- Shorter warning
- Shorter duration

b. Pollutants

- More varied
- More toxic
- More concentrated
- Possibly flammable, explosive, or corrosive

c. Meteorology

- Not restricted to poor dispersion conditions such as those requiring an Atmospheric Stagnation Advisory

d. Geography

- Smaller affected area
- Often specific for types of pollutants

e. Effects

- Potentially catastrophic in affected area
- Often deleterious to other animals, plants and inanimate materials

f. Responsibilities

- Public safety officials or emergency response team in primary role
- Air Pollution Control (APC) agency in a supporting role

Although the manual deals with all aspects of accidental-episode response activity, it aims particularly to define the role of the local APC agency. Response to this situation is quite different from action taken during a prolonged episode that results from meteorological stagnation.

This manual should also be useful to industries where hazardous materials are handled or produced. However, in order that the document have wide appeal, detailed engineering treatment of specific hazardous chemicals is reserved for the Appendices.

1.2 APC AGENCY INITIATIVES

State and local APC agencies are urged to review existing capabilities and procedures for response to accidental episodes within their respective jurisdictional areas. An APC agency can best provide services by participating in a Contingency Plan. A Contingency Plan is a formal arrangement whereby the personnel and resources of numerous community organizations, public and private, civil and military, are marshalled and employed in accordance with prescribed organization and procedures to minimize and counteract the effects of an accidental episode. The following actions are recommended:

- If no Contingency Plan or organization to handle chemical spills exists, take the initiative in getting one started. As a start, recommend to government executives and public safety officials that a meeting be held for discussion on the need for such a plan and organization.
- If contingency responsibilities are recognized, but are placed entirely in the hands of public safety officials, recommend that a more broadly based organization be developed that incorporates scientific and technical experts, and that a documented Plan be implemented.
- If both Plan and organization exist, review them for adequacy and recommend additions or modifications that serve to improve effectiveness. In particular, ascertain if there is a need for APC participation and if so, recommend that appropriate provision therefor be incorporated into the modifications.

- If both Plan and organization appear to be satisfactory, recommend that their effectiveness be tested by holding periodic drills with simulated random spills of different hazardous materials.

1.3 REQUIREMENTS FOR STATIONARY SOURCES

With regard to stationary sources, recommendations by an APC office carry added weight as a consequence of the Federal Clean Air Act Amendments and State Implementation Plans. Emission inventories, permit systems, and emergency episode plans required by this legislation can help to bring APC agencies into closer working relationship with local industries on matters of air quality.* APC agencies should take the opportunity to encourage industries that handle hazardous material to coordinate their respective safety programs with public and private emergency organizations in their community, and where possible, to join them under a formal Contingency Plan.

The material in this manual is expected to provide support for these recommended actions.

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* See Regulations for Preparation, Adoption, and Submittal of Implementation Plans, Part 420, Chapter IV, Title 42, Code of Federal Regulations, published in Federal Register, Vol. 36, No. 158, August 14, 1971. See especially 420.16 Prevention of air pollution emergency episodes, (c), which requires each stationary source emitting 100 tons per year or more of a common pollutant to file a contingency plan that includes emission control actions in the event of a general or single source episode.

2. AIR POLLUTION CONTROL AGENCY CONTINGENCY ACTION

2.1 A GROWING ROLE FOR AIR POLLUTION CONTROL (APC) AGENCIES

Air Pollution Control agencies in several of the more heavily industrialized States are presently geared to respond to accidental episodes and have done so on many occasions. In several cases the APC official was the highest ranking State official on the scene, and he found himself directing the actions of police, firemen, and others dispatched to the area. This involvement contrasts sharply with the minimal role exercised by most APC agencies around the country. Of the 260 or so State and local APC offices throughout the United States, the overwhelming majority could provide only meager support if requested. However, even the smaller agencies are rapidly being strengthened pursuant to recent legislation. In time, all agencies may be prepared for active involvement in contingency action. They have already become better known in their communities as they undertake a wider range of responsibility in air quality control programs. More and more they will be consulted for expertise on atmospheric contamination problems of whatever origin.

2.2 CONTINGENCY PLAN PARTICIPATION

Within the framework of a Contingency Plan, the APC agency should have responsibilities that are consistent with its technical capabilities. Public safety responsibilities should be executed only by the participating members that are legally constituted for these functions, principally the departments of police, fire, civil defense, and emergency (disaster) services. An effective Contingency Plan should provide for two main centers of activity:

- The Emergency Operations Center (EOC), which serves as semi-permanent headquarters for the Chief Operations Authority, who plans and directs the coordinated overall activities of all Contingency Plan participants.

- The accidental episode site, at which all direct measures are applied to contain, neutralize, and dispose of the hazardous emission and carry on evacuation and recovery operations, all under the direction of the On-Scene Commander.

A conceptualized view of an accidental episode is shown in Figure 2-1. Details on the development and implementation of a Contingency Plan are provided in Part II of this manual.

2.3 APC AGENCY TECHNICAL SUPPORT

The most common questions on accidental episodes that APC agencies are asked are of the two following types:

1. What are the physical, chemical, and physiological characteristics of the released chemical, and what is the nature of the threat?
2. What areas will be affected by the spread of material, and what is the required timetable for responsive action?

A principal aim of this manual is to enable APC offices to provide useful answers to these questions. To answer the first question, an agency will utilize its resources for field monitoring and detection and chemical analysis. For the second, it will apply techniques for estimating the extent of downwind hazard. While other Contingency Plan participants could provide one or the other of these services, only the APC agency can provide both and should therefore be assigned these responsibilities. Furthermore, the legitimate role of the APC agency should be limited to this area of technical support.

As described in this manual, capabilities for field monitoring, chemical analysis, and hazard area prediction are presently available only at the larger APC agencies. However, they are cited as desirable goals for smaller agencies as well, even in communities with populations of 50,000 or less. It is hoped the manual will spur an increasing number of them to gear for these emergency services.

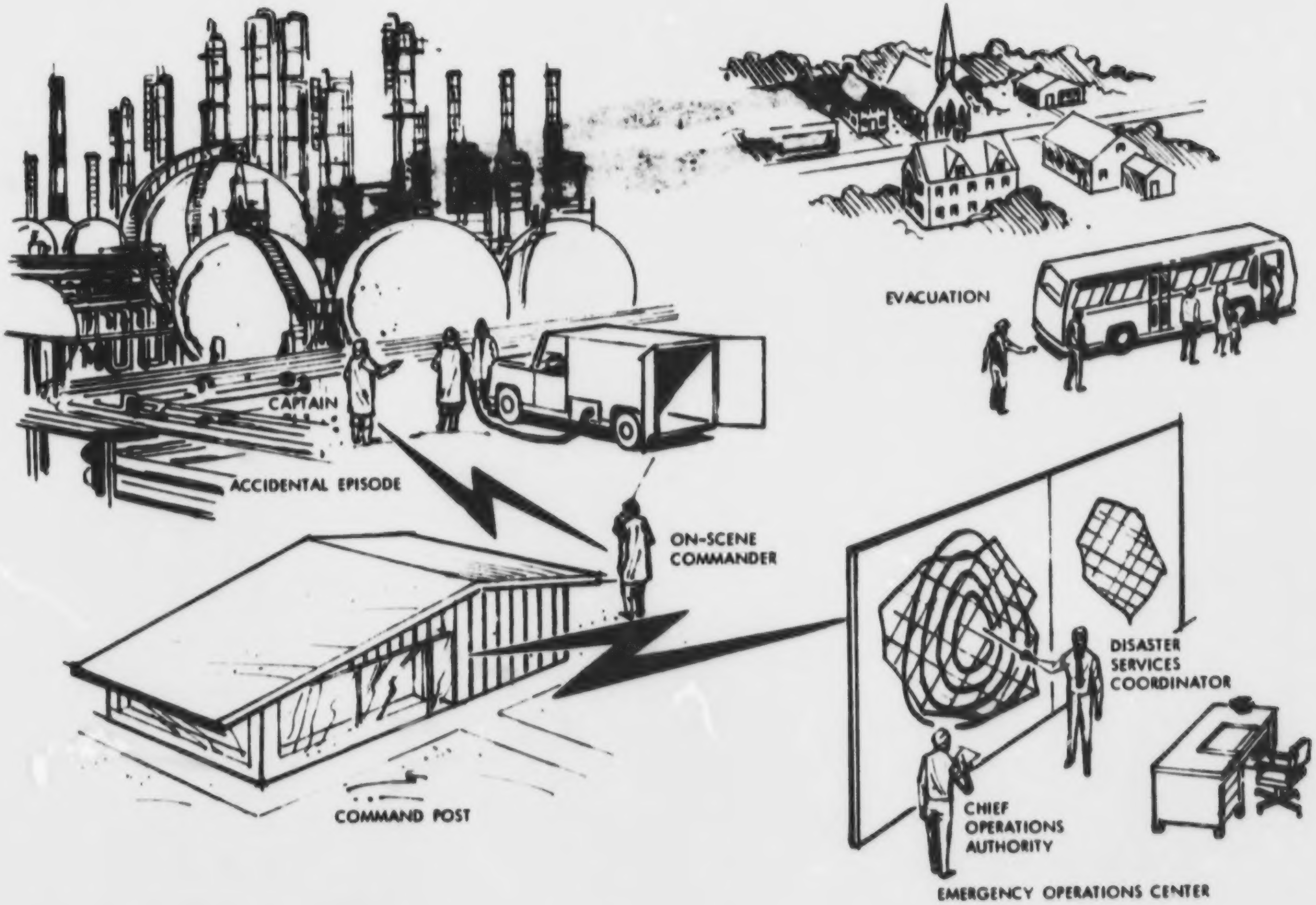
CAPTAIN
ACCIDENTAL EPISODE
EVACUATION
ON-SCENE COMMANDER
COMMAND POST
DISASTER SERVICES COORDINATOR
CHIEF OPERATIONS AUTHORITY
EMERGENCY OPERATIONS CENTER

Figure 2-1. Panorama of Accidental-Episode Events

2.4 STANDARD OPERATING PROCEDURES (SOP) FOR APC AGENCY PARTICIPANTS

The following outlines typical Standard Operating Procedures for APC agency participants in a Contingency Plan. It is designed to be part of an overall SOP for all Contingency Plan participants, which is presented in Part II of the manual. The following three phases are covered:

- Readiness
- Alert procedures
- Post-event procedures

2.4.1 Readiness

The APC office should maintain a state of readiness in order to respond upon notification of an accidental episode for which APC services are required. Readiness should not impose inordinate requirements upon the agency, since in most areas accidental episodes that could involve the agency are relatively infrequent events. A well-run organization with good housekeeping practices will find itself prepared for emergency services with very little additional effort. The following items are of particular importance for accidental-episode readiness. Daily use of check lists will help to keep these items in order.

2.4.1.1 Duty Roster

Provision should be made for a Duty Officer to be available at all times outside of regular office hours. This assignment, which should be rotated among members of the scientific and technical staff, does not require a physical presence at the office, but only a point of contact. The names and telephone numbers of all on the Duty Officer assignment list, along with the latest duty roster, should be on file at the local Emergency Operations Center.

2.4.1.2 Equipment

All equipment should be maintained in good working order. Equipment that is particularly required for use during an accidental episode includes:

- Vehicles (official and personal)
- Detection kits (see Sec. 2.5)
- Meteorological sensors, principally for wind direction and speed
- Protective gear: clothing, masks, gloves, etc.
- Communications equipment as required by the Contingency Plan
- Chemical laboratory equipment and supplies, especially for a mobile laboratory if available.

2.4.1.3 Documentation

The following are required:

- A "Ready Reference Shelf" consisting of recommended reference sources on accidental episodes
- Set of templates for estimating hazard area (provided herewith)
- Log book to record events and action taken.

2.4.2 Alert Procedures

Figure 2-2 shows a diagram of typical Contingency Plan procedures for APC agency participants during an accidental episode.

2.4.2.1 Activation

APC agency participation may be enlisted only when an accidental episode poses an imminent or potential threat to persons, or when the released hazardous material requires further identification. The Contingency Plan described in Part II of the manual defines three Alert stages according to the severity of the event, and provides for APC agency

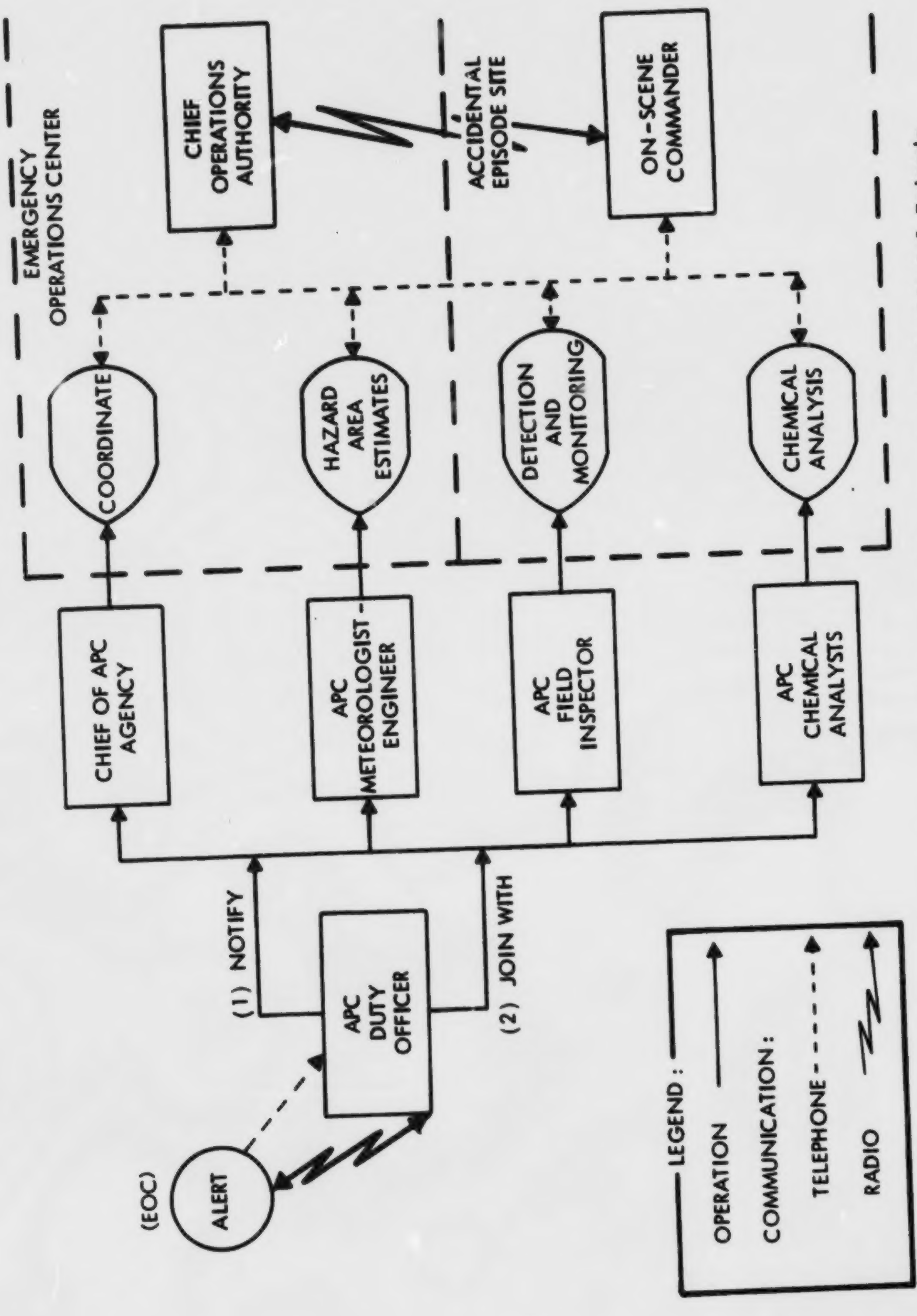
EMERGENCY OPERATIONS CENTER
ACCIDENTAL EPISODE SITE
(EOC)
ALERT
APC DUTY OFFICER
(1) NOTIFY
(2) JOIN WITH
CHIEF OF APC AGENCY
APC METEOROLOGIST-ENGINEER
APC FIELD INSPECTOR
APC CHEMICAL ANALYSTS
COORDINATE
HAZARD AREA ESTIMATES
DETECTION AND MONITORING
CHEMICAL ANALYSIS
CHIEF OPERATIONS AUTHORITY
ON-SCENE COMMANDER
LEGEND:
OPERATION
COMMUNICATION:
TELEPHONE
RADIO

Figure 2-2. Typical Contingency Plan Participation of APC Agency During Accidental Episode

activation during a Second or Third Stage Alert. When the Alert is declared, the EOC notifies the APC Duty Officer by telephone or shortwave radio, as prearranged. The Duty Officer contacts the agency chief and the staff members who are designated accidental-episode participants. These include a field inspector, a chemical analyst, a meteorologist/engineer, or their equivalents. The Duty Officer may himself be one of these specialists, or he may assist the staff as required.

2.4.2.2 Detection and Monitoring

The first persons on the scene of an accidental episode may be able to furnish a preliminary estimate of the dimensions of the toxic cloud and the direction and speed of its movement. In many cases the hazardous material itself may be identified. However, when these attempts to identify and monitor the emission have failed, the EOC may declare a Second or Third Stage Alert and request the aid of APC agency specialists.

APC field inspectors and chemists will be assigned to handle the duties of detection, monitoring, and chemical analysis. Smaller agencies may have only one person to do all the field monitoring, detection, and chemical analysis, while in larger agencies half a dozen or more chemists, sanitary engineers, and industrial hygienists may be on tap, in addition to field inspectors. Equipment items of a few agencies include portable gas chromatographs, ultraviolet and infrared analyzers, and spectrometers, transported to the scene in a mobile laboratory.

When dispatched to the accidental-episode site, APC participants will proceed as follows:

1. Drive to the site in an equipped APC vehicle (car, utility van, station wagon, trailer, or mobile laboratory).
2. Receive instructions from the On-Scene Commander
3. Observe the toxic cloud and its features, noting especially:

   a. Whether gas is escaping directly from its container or evaporating from a liquid spill
   b. If a liquid spill, the approximate area covered by the spillage
   c. The approximate rate of gas generation into the atmosphere
   d. The type and size of container from which the material is emanating (for an estimate of duration of spillage)
   e. Location of an intended sampling point, and coordinates of the point with reference to the source and center line of the cloud.
   f. The approximate rate of movement downwind, by timing an identifiable puff within the toxic cloud
   g. Atmospheric stability estimated from cloud behavior (e.g., vertical transport) or other indications.

4. Don protective gear.
5. Carry grab sample collectors such as mylar bags, absorbent material, or evacuated bulbs.
6. If mylar bags or absorbent material, carry a high-volume aspirator that is powered by automobile or self-contained battery.
7. Obtain an adequate amount of sample.
8. Return to the APC vehicle near the Command Post.
9. Analyze the sample (See Section 3).
10. Obtain essential data on the hazardous material (toxicity, flammability, reactivity with air, water, and extinguisher solutions, countermeasures, disposal methods, etc.) from reference material in the APC vehicle or by communication with the participant at the EOC or the APC agency office who has access to the Ready Reference Shelf.
11. Relay above information to the On-Scene Commander. (The Chief Operations Authority at the EOC will receive the data simultaneously.)

12. Relay data from Step 3. to the APC meteorologist at the EOC or APC agency office. If time permits, use a hand-held or tripod-supported wind set to obtain readings of wind direction and speed. If possible, obtain a 5-minute average from six readings of each parameter taken at 1-minute intervals. Relay data to the meteorologist (See Sec. 2.4.2.3).
13. Repeat Steps 5 through 11 as required.
14. Enter all data and related information into an engineering notebook.

Grab samples of the toxic cloud are analyzed in the APC vehicle parked near the Command Post. One or more of the following techniques may be utilized:

1. Detection kit (See Section 3.1).
2. Gas chromatograph or other equipment utilizing physical principles.
3. Other fast-detection laboratory techniques described in reference texts such as Ruch's "Chemical Detection of Gaseous Pollutants" (See Appendix A.2).

These techniques help to establish the identification and ambient concentration of contaminants at the sampling point. The data will be relayed to the APC meteorologist, who may then be able to estimate maximum concentrations along the center line.

The detection kit is limited to a small number of unknown materials that can be analyzed. By the other methods a much larger number of chemicals can be analyzed, and measurements are more accurate than those provided by the kit. The rise and fall of concentration can be closely followed by repeated sampling at the same spot.

2.4.2.3 Hazard Area Estimates

Providing estimates of the downwind hazard area ("exclusion area") that results from the atmospheric dispersion of hazardous material is a specialty of the APC agency. This duty is assigned to an APC specialist such as a meteorologist or other professional (e.g., chemist, engineer, industrial hygienist, toxicologist) who has acquired added meteorological capability. When his assistance is requested during an Alert, he will proceed in accordance with the Contingency Plan to his assigned place of operation, which may be either the EOC or the APC agency office. There he will:

1. Be briefed by the Chief Operations Authority.
2. Communicate directly with observers at the accidental-episode site (APC field inspectors, etc.) to receive current meteorological and hazardous emission data.
3. Refer to posted 1:24,000 U. S. Geological Survey maps of the local area to note location of the accidental episode, character of terrain downwind from the site, and major obstructions to wind flow.
4. Telephone the nearest National Weather Service forecaster to discuss reports and predictions on weather, wind, and stability for the general area.
5. Determine which template to use for estimating the hazard area (See Sec. 3.2 and templates inside back cover of the manual).
6. Superimpose appropriate template over the posted USGS map and outline the hazard area in accordance with instructions in Sec. 3.2.
7. Advise Chief Operations Authority of results.
8. Repeat above for all updated observational data.

9. If more accurate wind information is available through the use of instrumentation on the scene, prepare a more accurate estimate of the hazard area if desired, using the method shown in Turner's Workbook (See Appendix B, Ref. 16), page 55, Problem 26.

10. Advise Chief Operations Authority that decisions on the evacuation of persons from the hazard area need not await completion of the more accurate estimate. Evacuation in progress could be modified in line with the updated information.

2.4.2.4 Meteorological Data

For best results in predicting downwind hazard area, on-the-scene meteorological observations should be taken. While the first estimates could be provided by the On-Scene Commander (or an assistant), more accurate data may be obtained by APC field personnel upon arrival on site. As envisioned, APC field personnel will utilize portable wind sets and other meteorological equipment. More likely, the mobile laboratory will have this equipment already installed, and need only deploy it in a representative location. Coupled with expert visual observations of cloudiness, visibility, and other parameters associated with atmospheric stability, the data will be communicated to APC specialists assigned to headquarters for the purpose of providing hazard area estimates.

In the absence of on-site measurements, the nearest office of the National Weather Service should be contacted for an estimate or prediction of required parameters. Prior arrangement should be made for use of an emergency or unlisted telephone number. At a number of smaller stations, it may be necessary for special requests to be relayed to the Regional Forecast Center, but resulting delays in providing required information should be minimal.

In many air pollution prone cities, the National Weather Service operates or plans to operate an Environmental Meteorological Support Unit

(EMSU), which provides special types of observations and predictions in support of the local APC agency*. More precise hazard area forecasts can be made by the APC specialist with the use of high resolution data provided by a nearby EMSU unit. None of these data can be considered more than second best to that obtained by direct observation at the scene of the accidental episode, and that responsibility can best be handled by APC field personnel.

2.4.2.5 Coordination

The chief of the APC agency may be a team participant either as one of the technical specialists or as an ex-officio Contingency Plan coordinator of the efforts of his staff members. The extent of participation will depend upon the need for his active assistance during the event. Even in a less active role, however, he should plan to be present in order to observe:

- The individual performances of APC specialists
- Their effectiveness as members of a larger team
- Overall performance and results of the Contingency plan effort.

2.4.3 Post-Event Procedures

Several days after the accidental episode, when the events are still fresh in mind yet sufficiently removed to be viewed in perspective, a critique should be made of all aspects of the APC agency effort. Of particular interest are the timeliness, accuracy, responsiveness, and usefulness of data and recommendations provided by APC team members. The following sources of information will be used:

- Individual debriefings by APC agency participants, including the agency chief.
- Logbooks and engineering notebooks maintained during the event

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*As of September, 1971, EMSU programs are installed in 14 cities: New York, Washington, Philadelphia, Chicago, Denver, St. Louis, Louisville, Cleveland, San Francisco, Los Angeles, Boston, Houston, Seattle, and Pittsburgh.

- News media accounts, including comments by survivors and evacuees
- Comments of other Contingency Plan participants, particularly the Chief Operations Authority and the On-Scene Commander.

Findings and recommendations of the critique should be documented, along with data on manpower and finances charged to the event.

3. APC CHEMICAL DETECTION TECHNIQUES

3.1 DETECTION KITS

It is assumed that a multiple-purpose detection kit will be one of the standard items of equipment for an APC field inspector or chemist on an accidental-episode assignment. Kits of this sort could be prepackaged on order from any of several manufacturers, including Mine Safety Appliances Company, Gelman Instruments Company, National Environmental Instruments, Inc. (UNICO), Kittegawa (Japan) and Draeger (Germany). A separate reagent-filled tube is used for the detection of each chemical. For certain chemicals, pyrolyzers and other accessories are required. A summary data sheet issued by one company lists close to 80 gaseous or vaporous chemicals for which detection tubes are available.

3.1.1 Principle of Operation

A typical gas detector kit contains a single-stroke hand pump of 100 ml capacity, and one or more sets of micro-orifice tubes mounted in a case. The gas sample is aspirated into the pump, the amount drawn in being measured by calibrations on the handle. A prescribed amount of sample is forced back through a hollow needle into a detector tube. Analysis is based on the chemical reaction of the detector tube reagent to the presence of the gas being sampled. A positive response is indicated by a pronounced color change in the reagent. Gas concentration is estimated by comparison of the tube with a reference chart calibrated either by color intensity or length-of-stain. Figure 3-1 shows a typical detector kit.

3.1.2 Sensitivity Requirement

Each detector tube is designed for sensitivity to a specified range of concentrations. At the low concentration end of the scale, concentrations below the Threshold Limit Value (TLV) are detected. This is the highest concentration to which the average employee can be exposed over an 8-hour period without deleterious physiological effects. For use in accidental episodes, the range should begin just below the Emergency Exposure Limit (EEL) or the Public Exposure Limit (PEL), which are defined

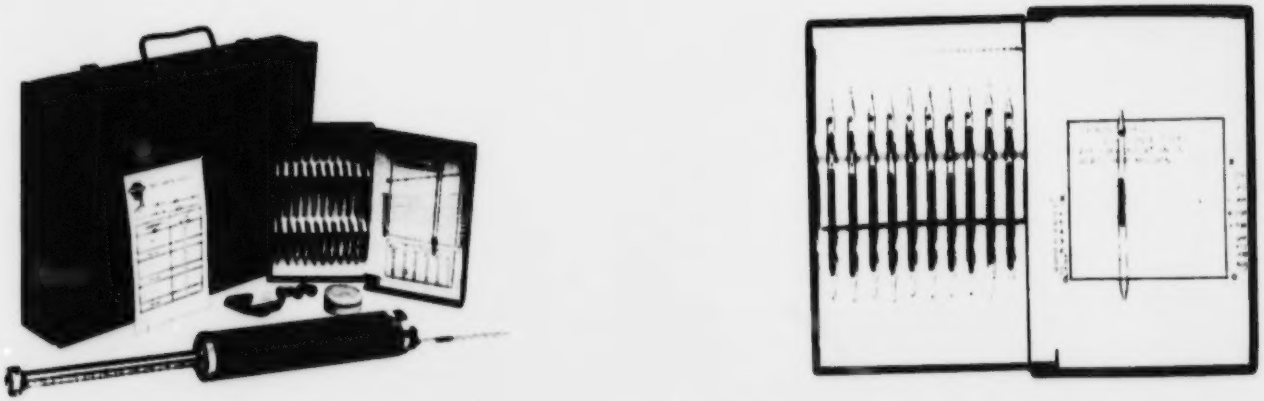


Figure 3-1. Example of a Chemical Detector Tube Kit

on the basis of permissible concentration excursions lasting 60 minutes or less. For most hazardous chemicals, proposed EEL and PEL concentrations have not been agreed upon by various committees on standards, and it is far from the present intent to enter into this area of uncertainty. However, highly simplified estimates proposed by the 1970 edition of Threshold Limit Values, which are published and selectively revised annually by the American Conference of Governmental Industrial Hygienists, have been adopted for the purposes of this manual because errors, if any, tend to be on the side of conservatism. The following relations are used:

If the TLV Lies Between:	Multiply it by the following factor to get EEL:
0 and 1	3
1 and 10	2
10 and 100	1.5
100 and 1000	1.25

Threshold Limit Values published and selectively revised annually by the American Conference of Governmental Industrial Hygienists include "Ceiling Values" for certain substances, indicated by a reference letter "C." For a substance to which it applies, the Ceiling Value is a concentration that should not be exceeded. Below the Ceiling Value, time-weighted average concentrations produce little physiological effect. Above this value, the substance is fast-acting even for short period excursions.

3.1.3 Priority List of Chemicals

Obviously, the detection kit recommended for use to identify and measure concentrations of unknown material in a chemical spill would have to be limited in size, hence in the number of chemicals that could be detected. For the purposes of this manual, a rating system was developed that led to an order of priority for hazardous chemicals to be considered. The final list of fifteen chemicals is as follows:

Hydrogen sulfide
Vinyl chloride
Ethylene oxide
Chlorine
Anhydrous ammonia
Acetaldehyde
Hydrogen cyanide
Acrylonitrile
Methanol
Benzene
Formaldehyde
Acetone
Butane(s)
Propane
Ethyl chloride

In addition, the APC agency should become familiar with hazardous chemicals that are frequently encountered either through manufacture in the local area or transport through it.

The rating system and development of the foregoing list, along with basic data on more than 50 of the most commonly used chemical products appear in Appendix A.

3.2 OTHER ON-THE-SPOT TESTING EQUIPMENT

A variety of test equipment and techniques is presently in use by some APC agencies for on-the-spot testing. Noxious gases, odors, vapors and phenomena for which tests can be made in the field and which require no laboratory analysis are:

Aldehydes
Ammonia
Aromatic hydrocarbons
  (benzene, etc.
Chlorine
Combustible gases and vapors
  (propane, butane, etc.)
Organic halides (vinyl, ethyl chloride)
Hydrogen cyanide
Hydrogen sulfide

Several types of equipment are utilized for these tests. They include sensitized papers or crayons, squeeze bulbs and ampules, burettes, titration cylinders, explosimeters, midget impingers and gas absorption cells, and other devices. Some are shown in Table 3-1 and Figure 3-2, which are taken from Chapter XI of the Air Pollution Control Field Operations Manual, PHS Publication No. 937. However, it would be more practical if a simple identification kit for field use in accidental episodes were available, as described in Section 3.1.

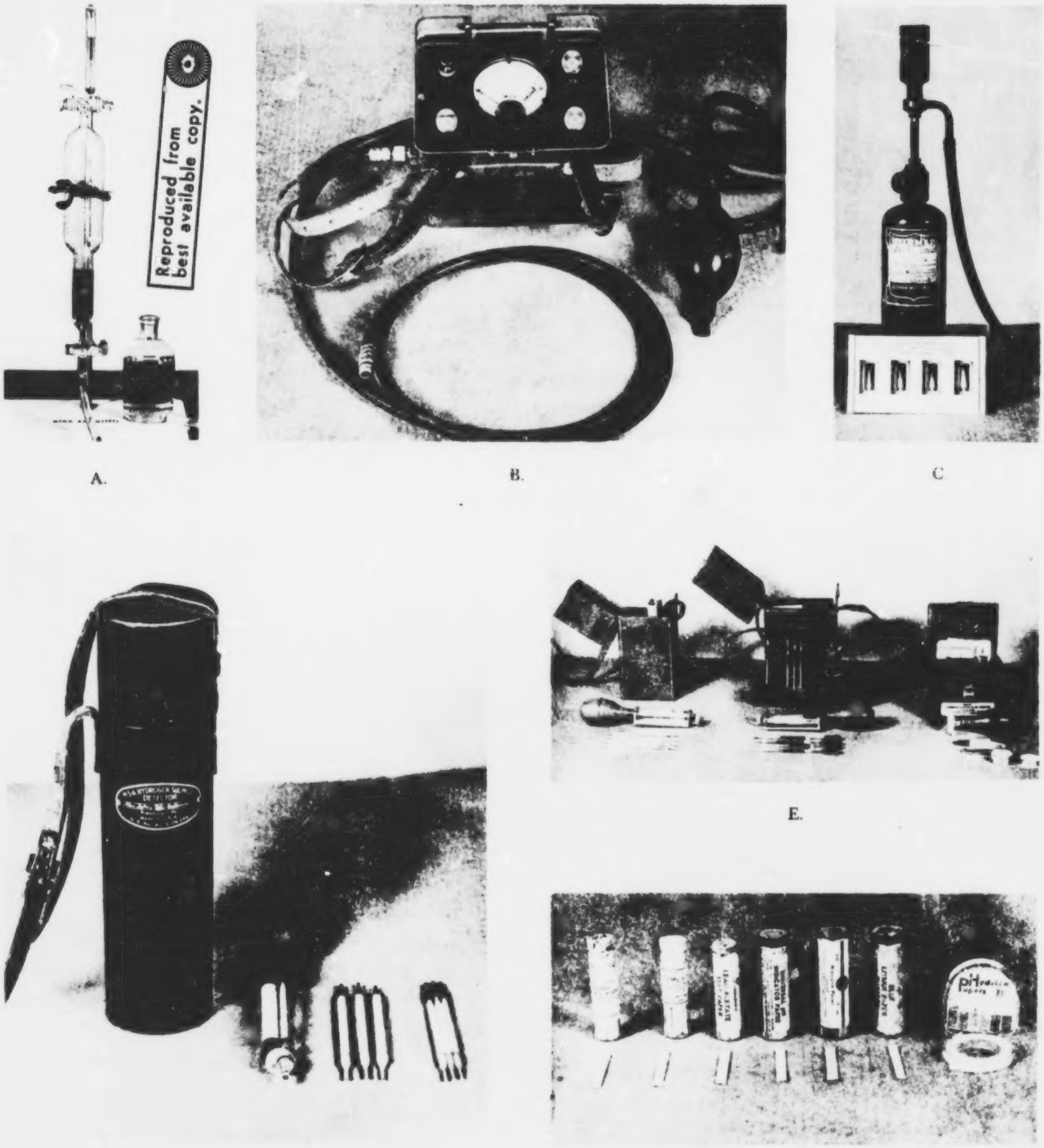
CONTAMINANT	REAGENT OR EQUIPMENT USED	TREATMENT OR REACTION OBSERVED	TIME REQUIRED			CONCENTRATION RANGE OF TEST	EIGHT-HOUR THRESHOLD LIMIT	SUFFICIENT WARNING WITHOUT TESTING
			a	b	c			
Aldehydes	Absorption in Sodium Bisulfite M.S.A. Midget Impinger	Iodometric Titration	10	5	10	0 - 1000 ppm	.5 to 5.0 ppm	Yes - Eye Irritation
Ammonia	Red Litmus & Stop Watch	Color Change to Blue	1	1	0	10 - 100 ppm	100 ppm	Yes - Odor
Aromatic Hydrocarbons (Benzene)	M.S.A. Aromatic Hydrocarbon Detector	Colors Treated Granules. Stain Length Measured.	10	2	0	0 - 100 ppm	25 ppm	Yes - Odor
Chlorine	O - Tolidine in the M.S.A. Midget Impinger	Color Intensity Compared to Standards	10	5	2	0 - 70 ppm	1 ppm	Yes - Odor for Immediately Dangerous Levels. No - for Low Conc.
Combustible Gases	M.S.A. Model 40 Combustible Gas Indicator	Direct Reading Instrument	1	2	2	0 - 20 x LEL	—	Some Yes - Odor
Hydrocyanic Acid Gas	M.S.A. Hydrocyanic Acid Gas Detector	Treated Granules Orange Color	10	2	0	0 - 50 ppm	10 ppm	Yes - Odor - by Trained Personnel
Hydrogen Sulfide	M.S.A. H_2S Detector	Treated Granules Change Color	1	2	0	0 - 50 ppm	20 ppm	No - Odor is not Reliable

a. Preparation in minutes

b. Test or Sampling

c. Calculation and Interpretation

Table 3-1. Contaminants Which Can Be Tested in the Field with Portable Devices



Reproduced from best available copy.

A. B. C

E.

D. F.

Figure 3-2. Portable field-testing equipment: A. Tutweiler apparatus; B. explosimeter; C. halide leak detector; D. squeeze bulbs and ampules for H_2S testing; E. squeeze bulbs and ampules, from left to right: CO, SO_2 (also used for HCN and aromatic hydrocarbons), and HF testers; F. test papers

3.3 CHEMICAL ANALYSIS PROCEDURES

Procedures for determining the identification and concentration of sampled airborne contaminants are detailed in a number of cited reference texts, and summarized in Ruch's "Chemical Detection of Gaseous Pollutants"*. The latter lists accepted tests for over 150 substances including all fifteen on the priority list (Sec. 3.1.3). They are described in Appendix A, Sec. A.2.

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* See Appendix B , Reference 4.

4. HAZARD AREA ESTIMATES

4.1 DEFINITION OF HAZARD AREA

The hazard area that results from a release of contaminant into the atmosphere is an area downwind of the source where ambient concentrations endanger the health and safety of persons exposed to the material for a relatively short period of time, on the order of an hour or less. It is also called an "exclusion area" since all persons within its delineated boundaries should be evacuated as quickly as possible.

4.2 THE PREDICTION MODEL

The basic expression for maximum (center line) concentration downwind from a source of airborne contaminant is:

$$\chi_{CL} = \frac{Q}{\pi \sigma_y \sigma_z \bar{u}}$$

where χ_{CL} = the concentration, usually expressed in micrograms of contaminant per cubic meter of air ($\mu g/m^3$)

Q = source strength or rate of contaminant generation, expressed as grams of airborne contaminant (gas or vapor) per second (g/sec)

σ_y = standard deviation of concentration crosswind through the toxic cloud, given in meters (m)

σ_z = standard deviation of concentration vertically through the toxic cloud, given in meters (m)

$\bar{u}$ = wind speed averaged over a discrete period of time, say 30 seconds, expressed in meters per second (1 m/sec = 2.3 mph)

π = 3.1416

The two standard deviations increase as the cloud spreads during downwind movement. Hence, the computed concentration, χ_{CL} refers to a given point downwind at which the cloud measurements are considered.

Downwind cloud dimensions also depend upon the intensity of turbulence in the atmospheric layers in which the cloud is moving. Turbulence results when the air is heated by the sun (thermal turbulence) or when it blows over rough ground or around obstacles (mechanical turbulence). On a typical sunny afternoon with gentle to moderate winds, the lower layer of the atmosphere exhibits pronounced turbulence, and is said to be unstable. Under these conditions a cloud of contaminants is buffeted laterally and vertically by turbulent gusts. It becomes diluted by the ambient air so that concentrations diminish rapidly downwind. On a typically clear, quiet night, the atmosphere is said to be stable, marked by the absence of turbulence. Under these conditions, a cloud of contaminants is carried by a light wind as a narrow plume in which concentrations at considerable distances from the source are still comparable with those near the source.

4.3 TOXICITY FACTOR

For hazard area estimates, the additional factor of toxicity must be considered. Given two gaseous contaminants, for example, acrylonitrile and hydrogen cyanide, escaping into the atmosphere at the same rate and traveling downwind over a given terrain under identical atmospheric conditions, the pattern and values of ambient concentration will be the same but the more toxic substance, hydrogen cyanide, will be a threat to health and safety farther downwind and over a larger area than will acrylonitrile. For the fifteen chemicals that rated highest in potential hazard, the concentrations listed in Table 4-1 were considered to define the hazard area boundaries.

Chemical	Threshold Limit Value (1970) (mg/m^3)*	Hazard Area Value (mg/m^3)
Formaldehyde	3c	3
Chlorine	3	6
Hydrogen cyanide	11 (skin)	17
Hydrogen sulfide	12	18
Anhydrous ammonia	18	27
Acrylonitrile	45 (skin)	68
Benzene	80c (skin)	80
Ethylene oxide	90	135
Methanol	260	315
Acetaldehyde	360	450
Vinyl chloride	770c	770
Propane (L.P.G.)	1800	2250
Butanes (estimated)	2000	2500
Acetone	2400	3000
Ethyl chloride	2600	3250

Table 4-1. Hazard Area Limits for the Fifteen Highest Rated Chemicals.

*American Conference of Government Industrial Hygienists; includes intended changes for 1970.

c = ceiling value

4.4 HAZARD AREA TEMPLATES

For a first approximation of potential hazard area downwind from the site of an accidental episode, the use of templates is recommended. Three templates labeled Figures 4-1, 4-2, and 4-3 will be found inside the back cover of this manual. They are designed for Unstable, Neutral, and Stable atmospheric conditions, respectively, and for use as overlays on 1:24,000 U. S. Geological Survey maps. They assume a source strength, Q, of 1 kg/sec and, downwind speed $\overline{u}$ of 3 m/sec (7 mph). The templates will be easier to handle and maintain if they are mounted onto plexiglass or similar hard, transparent surface.

Downwind concentrations were computed from Turner's Workbook* for Pasquill stability categories B, D, and F, respectively. For each case, wind direction variability was considered in accordance with the following total angular range:

- For Category B, 80 degrees
- For Category D, 30 degrees
- For Category F, 15 degrees

These are approximately four standard deviations of the lateral wind fluctuations that are observed for each typical case.**

To use the template, simply place the zero distance point over the accidental-episode location and rotate the template so that its center line is oriented in the downwind direction. Trace onto the base map the hazard area identified by the name of the chemical involved, including all of the delineated area between zero distance and the labeled isopleth.

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* See Appendix B , Reference 16

** See Slade, D. H. (ed.), "Meteorology and Atomic Energy." U. S. Atomic Energy Commission, TID 24190, July 1968; p. 130. Table 4-5 refers to near-equivalent stability categories of the Brookhaven Trace Type System.

4.5 SOURCE STRENGTH CONSIDERATIONS

4.5.1 Source Strengths Other Than 1 kg/sec.

The templates have been constructed on the basis of an assumed value for Q, source strength, of 1 kg/sec. (about 4 tons per day). This emission rate is typical of what has been observed or calculated for rocket fuel spills. It is used here because no other estimates are available, and because exclusion areas based on a more accurately known value of source strength can readily be determined by means of the templates. If source strength in a given accidental episode is known or estimated to be other than 1 kg/sec., the shape of the appropriate template would not be altered but the downwind distance would have to be adjusted accordingly. The method is as follows:

1. From Table 4-1, read the Hazard Area Value for the chemical of interest.
2. Divide this value by the actual emission rate in kg/sec. Call this quotient the equivalent concentration.
3. Select the template for the actual stability condition.
4. Find the isopleth position for the equivalent concentration.
5. Trace the hazard area out to the isopleth of equivalent concentration.

EXAMPLE:

Hydrogen sulfide is released at the rate of 3 kg/sec. under Neutral Conditions. To what distance from the source does the actual hazard area extend?

PROCEDURE:

1. From Table 4-1, the Hazard Area Value for Hydrogen Sulfide is 18 mg/m^3.
2. Divide that value by 3 (kg/sec), giving an equivalent concentration of 6 mg/m^3.

3. On Figure 4-2, for Neutral Conditions, the 6 mg/m^3 isopleth is found by interpolation to lie directly downwind at about the 4.0 km mark.

4. The hazard area is all that is enclosed by the template out to 4.0 km.

NOTE: It is incorrect to estimate the actual area by applying the factor of 3 to the downwind distance. In the example, the downwind distance for 1 kg/sec. is about 2.2 km, for 3 kg/sec. about 4.0 km.

The relation between concentration and downwind distance is not linear. Concentration is linearly related to source strength, Q, and is inversely proportional to wind speed, $\bar{u}$. If the values of these parameters are different from those used in constructing the templates, the effect on concentration must first be determined and the downwind distance then located on the basis of where the limiting isopleth would be drawn for conditions as given. See other examples that follow.

4.5.2 Release Duration

From an assumed value of source strength it is possible to estimate how long it will take for all the toxic material to flow out of its container. For example, chlorine is shipped as a liquid under pressure in steel containers. Cylinders normally hold 100 to 150 pounds, larger containers hold 2000 pounds, and single-unit tank cars hold 16, 30, and 55 tons. Newer tank cars that hold 85 tons and 90 tons are now in use as well. Chlorine is also shipped in multitank barges, up to 1100 tons, and in tank trucks holding approximately 6 tons. Excess flow valves are designed to keep the flow rate under 0.9 kg/sec. from tank cars and tank trucks, and under 1.9 kg/sec. from barges. A tank car that holds 30 tons of chlorine releasing at a uniform rate of 1 kg/sec. will take about 7.5 hours for all the chlorine to be released. The gas may empty much more rapidly in the event the container is deeply ruptured. In general, the emission rate is seldom uniform over a long period of time.

4.5.3 Spillage of Volatile Liquids

Hazardous substances that are transported as liquids may have been either liquid or gaseous at normal pressure and temperature. In the latter case, the gases are liquefied and pressurized to several atmospheres within their container. When vented to the atmosphere, pressurized liquid rapidly returns to the gaseous state, carrying along aerosolized liquid particles that vaporize in a few seconds. In such cases, the source strength may be assumed to be 100% of the material emitted.

However, other hazardous substances that are liquid though volatile at normal pressure and temperature may spill from their container to the ground, and enter the atmosphere only through vaporization. In such cases the source strength for the same quantity of spill as a liquefied gas will be somewhat less than that of the gas by a factor that depends on its rate of evaporation. The rate of evaporation is not constant; it depends upon the temperature, pressure, and wind speed of interfacing ambient air, and in the case of hygroscopic material like anhydrous ammonia, on the relative humidity as well. It also depends upon its vapor pressure curve. Figure 4-4, adapted from Siewert*, shows the relation between source strength and vapor pressure as determined for a variety of rocket fuels, some of which are transported under cryogenic conditions. His original chart gives source strength in pounds per second for a liquid spill that covers 600 square feet, assuming a wind of 10 mph (4.3 m/sec.), air temperature of 80°F, and no absorption or heating by the ground.

In the event of a volatile liquid spillage, vapor source strength, Q, may be determined by the following procedure:

1. Estimate the rate of liquid spillage, expressed in kg/sec.
2. From Appendix A , Table A-5, read the vapor pressure at 20°C for the chemical in question (last column).

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*R. D. Siewert, personal communication, 1971.

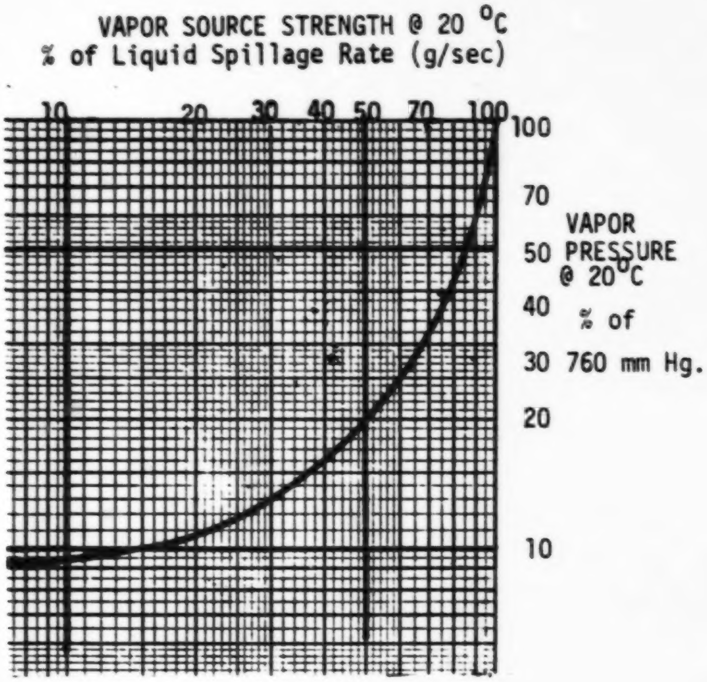

Figure 4-4. Vapor Source Strength, expressed as a Percentage of Liquid Spillage Rate, shown as a function of Vapor Pressure at 20°C (adapted from Siewert)

3. Express the vapor pressure as a percentage of 760 mm. of Hg.
4. From Figure 4-4, find this percentage along the ordinate, move left to where this value intersects the curve, and read the abscissa.
5. Determine vapor source strength from the percentage of liquid spillage rate.

EXAMPLE:

A tank truck filled with acetone at ambient pressure is ruptured, and the chemical spills to the ground at an estimated rate of 1 gal/sec. Specific gravity of acetone is about 0.8. What is the vapor source strength, Q?

PROCEDURE:

1. Spillage rate of 1 gal/sec. = 3.8 liters/sec. = 3.8 x 0.8, or about 3 kg/sec.
2. Table A-5 gives vapor pressure of acetone at 20°C as 175 mm Hg.
3. Acetone vapor pressure is therefore 175/760 = 23%, for ordinate value.
4. From Figure 4-4, abscissa is 56%.
5. Vapor source strength, Q, is 56% of 3 kg/sec, or 1.7 kg/sec.

4.6 WIND SPEED CONSIDERATIONS

As previously noted, the templates are constructed on the basis of a mean wind speed, $\bar{u}$, of 3 m/sec. (7 mph). Should the reported wind be other than 3 m/sec., the hazard area estimate is adjusted as follows:

1. From Table 4-1, read the Hazard Area Value for the chemical of interest.
2. Divide this value by 3.

3. Multiply the quotient by the reported wind speed. Call this product the equivalent concentration.
4. Select the template for the actual stability condition.
5. Find the isopleth position for the equivalent concentration.
6. Trace the hazard area out to the isopleth of equivalent concentration.

EXAMPLE:

Anhydrous ammonia is released under Stable Conditions at the rate of 1 kg/sec. The wind speed is measured as 2 m/sec. To what distance from the source does the actual hazard area extend?

PROCEDURE:

1. From Table 4-1, the Hazard Area Value for Anhydrous Ammonia is 27 mg/m^3.
2. Dividing 27 by 3 gives 9.
3. Multiplying 9 by 2 gives 18 mg/m^3, which is the equivalent concentration.
4. The appropriate template is Figure 4-3.
5. The isopleth position for 18 mg/m^3 is approximately 5.5 km downwind.
6. The hazard area is the total area inside the template between zero distance and 5.5 km.

NOTE: At 2 m/sec., the vaporous cloud will reach the 5.5 km downwind distance in 2750 sec., or about 46 min.

4.7 ADJUSTMENTS FOR TERRAIN

Predicted hazard areas represented by the templates may require adjustment for variations of terrain. This task can only be approached subjectively, guided by the analyst's familiarity with the threatened area. Nevertheless, the following generalities may be stated.

1. Winds under 5 m/sec (11 to 12 mph) tend to follow paths of least resistance: river channels, valleys, city avenues, etc.

2. Winds are diverted by obstacles such as prominent hills, and in cities by large buildings. With stronger winds that are forced upward, around, and over these obstacles, reverse eddies tend to appear on the lee side in which there are zones of increased and decreased concentrations of airborne contaminants. Hence, the lee side of a hill or building may not necessarily provide temporary safety from a toxic cloud.

3. If the wind travels upslope, gases that are significantly heavier than air may not be transported as far as the template shows. The pattern of concentration would be foreshortened, and contamination in the valley would be heavier than indicated by the template.

   This correction may be required for all of the 15 gases on the priority list with the exception of ammonia and hydrogen cyanide

4. If the wind travels downslope, gases that are significantly lighter than air, chiefly ammonia and to a lesser extent hydrogen cyanide, would appear in lower concentrations downwind than shown by the template.

4.8 ADJUSTMENTS FOR FIRE

The fire hazard has not been considered in construction of the templates. Many of the hazardous chemicals are highly flammable. In some cases ignition caused by a spark or open flame some distance downwind may flash back to the source, resulting in an initial explosion or fire of wide dimensions. Atmospheric dispersion models that include this phenomenon would have to consider the "stack effect" of the fire and the local atmospheric instability condition that rapidly develops near the source. Once in progress the fire tends to be concentrated at the source only, and the emanating cloud consists of combustion products that may or may not be toxic but are usually suffocating or highly irritating. Evacuation of people from an area farther than about 1 km downwind of the fire is seldom required.

APPENDIX A

HAZARDOUS MATERIALS

A.1 RATING SYSTEM

Specific hazardous chemicals that are treated in detail in this manual have been selected on the basis of a rating system. The rating system developed in the Battelle Report*, which was applied to the analogous spillage problem into a water medium, serves as a model for this purpose. In the transfer of methodology to the problem of airborne hazards, so much of the details have had to be altered that to all intents and purposes a new rating system has emerged.

Unlike the Battelle system, this system covers accidental episodes from stationary as well as mobile sources. The approach to scoring is different for the two types of sources. Accidental-episode potential for stationary sources has been assessed entirely on the basis of case statistics with the assumption that what is past is prologue. For mobile sources, the Battelle methodology and data have been adapted to present purposes by the addition of the hazardous chemical grading system used by the National Fire Protection Association** and an analogous grading scheme for volatility. Ratings for mobile sources are developed only partially from case statistics (accident probabilities for rail, truck, and water carriers), the other parameters being the total annual production and physical, chemical, and toxicological properties of transported materials.

Details of the rating system follow.

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* See Appendix F, Reference 8.

**See Appendix B, Reference 8.

A.1.1 Rating System Derivation

House Document No. 92-70, P. II-65, gives an expression for hazard risk of a spillage into a body of water. Neglecting the parameters that apply exclusively to water usage, the expression adapted for airborne contaminants may be stated as follows:

$$\overset{*}{R} = f(P, H, Q, E, T, M) \qquad (1)$$

where: $\overset{*}{R}$ = degree of risk

P = probability of a spill

H = product hazard

Q = quantity of the product

E = environmental conditions

T = time to detect release and begin response

M = mitigation factor (effectiveness of countermeasures)

Distinguishing stationary sources, s, from mobile sources, m:

$$\overset{*}{R} = f(H, E)\{g_s[P_s, Q_s, T_s, M_s] + g_m[P_m, Q_m, T_m, M_m]\} (2)$$

For a rigorous analysis, data for the independent variables could be obtained from a statistical analysis of all case histories on record, provided the required information were fully reported. However, full reporting has been done in only a handful of cases, including the more well known events recounted in Appendix C. In any event, for the purposes of this study it is not essential to have an absolute value for the rating of each chemical, but only a set of relative standings on the basis of major criteria. For example, we may assume that $T_s = T_m$ = constant; and that $M_s = M_f$ = another constant. The equation can then be divided through by these constants and simplified to read:

$$R = f(H,E)\{g_s[P_s,Q_s] + g_m[P_m,Q_m]\}$$

E is another parameter which would require intensive research to evaluate. It could be determined, but is it worth the effort, especially when its influence is felt in the good, hard statistics on accident probability? For the rest, there are several data sources that could be used, viz.:

H = H (Toxicity, Flammability, Reactivity, and Volatility)
Numbers for each of these properties could be derived from sources like MCA Safety Data Sheets, the Battelle Report (Dawson, et al.), HD 92-70, NFPA Manuals, Handbook of Chemistry and Physics, and "Ready Reference Shelf" textbooks.

P_s: Could be determined from the more than 1000 case studies published by the MCA.

Q_s: Listed for over 200 chemicals in the Battelle report, taken from a study by Booz, Allen and Hamilton quoted in that report.

Q_m: Apparently not available for each chemical despite an extensive literature search. Obviously Q_m is included in Q_s, that is, not all of a chemical that is manufactured gets to be transported. In-house use varies with each commodity and manufacturer. Again, since only a relative standing is needed, the assumption had to be made that $Q = Q_s = kQ_m$, with $k > 1$ and the same for each commodity.

As for f, g_s, g_m, R was assumed to have a power function relation of the following type:

$$f^*(R) = A \log S + B \log M,$$

Where $f^*(R)$ = a relative value for R

S = a score obtained by evaluating all MCA stationary source cases that involved the given commodity

M = a score obtained by evaluating the probability statistics listed in the Battelle report, multiplied by H, a number that expressed the combined hazard from toxicity, etc.

A,B = arbitrary constants that enable the entirely dissimilar scoring systems used for S and M to be made comparable

A.1.2 Stationary Sources

As mentioned, the basic reference for stationary sources is "Case Histories of Accidents in the Chemical Industry," which is a compilation of representative events from the year 1951 to date. Indices, which are cumulative from the beginning of record, include a breakdown of cases by specific chemical. Accidents that were not associated with airborne spread of hazardous material were excluded from the rating system, which arbitrarily scores events as follows:

No injuries or minor structural damage, score 1 point for each person exposed to the hazard.
Minor injuries (no lasting impedimentary effects) or moderate structural damage, points = number of injured persons times 2.
Major injuries or major structural damage, points = number of injured persons times 5.
Fatalities (direct or indirect), points = number of deaths times 10.

For example, Case 792, in which ethylene oxide was involved, resulted in 1 fatality, 3 major injuries, 6 minor injuries, and 12 exposures with no injuries. Points are (1 x 10) + (3 x 5) + (6 x 2) + (12 x 1) = 49. The twenty leading chemicals and their respective scores are listed in Table A-1.

Table A-1

List of 20 leading chemicals involved in accidental episodes from stationary sources.

Rank	Chemical	Score
1.	Hydrogen sulfide	411
2.	Chlorine	113
3.	Vinyl chloride	110
4.	Methyl parathion	91
5.	Xylol	64
6.	Ethylene oxide	60
7.	Acetaldehyde	50
8.	Nitrogen (compressed)	48
9.	Hydrogen cyanide	44
10.	Hydrogen (compressed)	39
11.	Anhydrous ammonia	38
12.	Oxygen (compressed)	31
13.	Aniline	25
14.	Methanol	22
15.	Acrylonitrile	20
	Sulfur dioxide	20
17.	Hydrogen peroxide	19
18.	Carbon monoxide	18
19.	Ethyl ether	17
20.	Benzene	15

A.1.3 Mobile Sources

Hazardous chemicals were scored in accordance with the following formula, which is based upon estimates of relative significance for the given parameters:

$$M = 3P_m Q^{1/2} (VH)^2$$

where M = score

P_m = Probability of accidental spillage during transport (see below)

Q = total annual production (in 10^4 tons)

V = volatility rating

H = hazard rating

$$P_m = .0028R_w + .0011R_r + .019R_t,$$

where R_w = percentage of material transported by water

R_r = percentage of material transported by rail

R_t = percentage of material transported by truck

and the coefficients are probabilities of accidental spillage by the respective carrier mode.

Probability and cargo loading data are extracted from the Battelle report*. The hazard rating, H, is the sum of NFPA ratings on a scale of 0 - 4 for each of three parameters, toxicity, flammability, and reactivity**. The volatility rating has been similarly developed on a scale of 1- 4 on the basis of vapor pressure at 20°C. The twenty leading chemicals and their respective scores, M, are listed in Table A-2.

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* For mobile sources, total annual amount of chemical transported would have been preferred to total annual output, but data for all chemicals were not available. See Appendix F, Reference 8.

** See Appendix B, Reference 8.

Table A-2

List of 20 leading chemicals potentially involved in accidental episodes from mobile sources.

Rank	Chemical	Score
1.	Ethylene oxide	19584
2.	Butadiene	14240
3.	Vinyl chloride	12628
4.	Ammonia (anhydrous)	10000
5.	Acetaldehyde	5856
6.	Ethylene dichloride	4215
7.	Formaldehyde	4144
8.	Fluorine	3976
9.	Propane	3920
10.	Hydrogen sulfide	3808
11.	Hydrogen cyanide	2970
12.	Acrylonitrile	2700
13.	Chlorine	2560
14.	Butane	2336
15.	Ethyl chloride	2328
16.	Benzene	2280
17.	Acetone	2220
18.	Methanol	2196
19.	Sulfuric acid	2152
20.	Butenes	2144

A.1.4 Combined Scores

Since the scoring system for stationary sources produces numbers that are orders of magnitude below those for mobile sources, compatibility for combination into a single rating is achieved by the use of a power function of stationary source scores. All scores are first expressed in logarithmic form. The logarithms of stationary source scores are multiplied by 1.5, which scales them up to make them more comparable with the logarithms of mobile source scores. Addition of logarithmic scores from stationary and mobile sources for each chemical results in the final scores and ranking, as shown in Table A-3.

Table A-3

Combined Scores for Stationary and Mobile Sources and Final Ranking of Hazardous Chemicals.

Rank	Chemical	Score (log)		
		Stat.	Mob.	Total
1.	Hydrogen sulfide	3.920	3.581	7.501
2.	Vinyl chloride	3.060	4.105	7.165
3.	Ethylene oxide	2.664	4.292	6.956
4.	Chlorine	3.080	3.408	6.488
5.	Anhydrous ammonia	2.370	4.000	6.370
6.	Acetaldehyde	2.548	3.768	6.316
7.	Hydrogen cyanide	2.465	3.473	5.938
8.	Acrylonitrile	1.950	3.431	5.381
9.	Methanol	2.010	3.342	5.352
10.	Benzene	1.762	3.358	5.120
	Runners-up			
11.	Formaldehyde	1.500	3.617	5.117
12.	Acetone	1.671	3.346	5.017
13.	Butanes	1.431	3.368	4.799
14.	Propane	1.049	3.593	4.642
15.	Ethyl chloride	0.903	3.367	4.270

Table A-4

VOLATILITY RATINGS OF HAZARDOUS MATERIALS

1. Gases at 20°C, Rating 4

LPG (including propane)
NH_3
Formaldehyde
Vinyl chloride
HCl
Ethylene oxide
Butadiene
Butanes
Butenes
Fluorine - F_2
HF
H_2S
Freon-12
Ethyl chloride
Cl_2
SO_2

2. Vapor pressure >100mm @ 20°C, Rating 3

Ethylene dichloride
Acetaldehyde
Acetone
CS_2
HCN

3. Vapor pressure $10 \leq p \leq 100$ mm @ 20°C, Rating 2

Benzene
Toluene
Methanol
Ethanol
Isopropanol
Cyclohexane
Acrylonitrite
CCl_4
Vinyl acetate
Perchlorethylene
Trichloroethylene
Methyl ethyl ketone
Methyl methacrylate
Trichlorocthane

4. Vapor pressure < 10mm @ 20°C, Rating 1

H_2SO_4
Styrene
Xylene
Acetic anydride
Phenol
Cumene
Phthalic anhydride
Dodecyl benzene
Tetraethyl lead
Acetone cyanohydrin
Aniline
Parathion
Butyl alcohol
Perchloric acid
Chlorosulfonic acid
Hexamethylene diamine
(subl. solid)

Hazardous Material	Annual Output (tons x 10^6)	Percentage Transported by			Toxicity			Flamm	React	Volatility	
		.0028	.0011	.019						Rating	Vapor Press $20^{\circ}C$
		Water	Rail	Truck	1 TLV (ppm)	TLV mg/m3	NFPA Rating				
Acetone	1.62	47.8	40.3	11.9	.001	2400	1^c	3^c	1^c	3	175 mm
Cumene (Isopropyl benzene)	1.60	79.6	14.8	5.6	skin .02	245				1	3 mm
Butane	1.38	47.8	40.3	11.9			0^c	4^c	0^c	4	Gas
Butenes	1:16	47.8	40.3	11.9						4	Gases
Acrylonitrile	1.15	47.8	40.3	11.9	skin .05	45	4	3	2	2	93 mm
Carbon tetrachloride	.97	47.8	40.3	11.9	skin .10	65	2^c	0^c	0^c	2	87 mm
Vinyl acetate	.83	47.8	40.3	11.9	*.10	*30	2	3	2	2	83 mm
Carbon disulfide	.82	47.8	40.3	11.9	skin .05	60	2	3	0	3	295 mm
Phthalic anhydride	.76	79.6	14.8	5.6	.50	12	1^s	1	2^s	1	1 mm
Fluorine	.70	1.1	85.7	12.9	F_2-10.0	0.2	4	0	3	4	Gas
Hydrogen Fluoride					HF.33	2.0	4	0	0	4	Gas
Perchloroethylene	.68	47.8	40.3	11.9	.01	670	1^c	0^c	1^c	2	13.5mm
Hexamethylenediamine	.65	47.8	40.3	11.9	mdt^c	mdt^c	2^s	1^s	1^s	1	subl.- solid
Hydrogen sulfide	.64	1.1	85.7	12.9	.01	15	3	4	0	4	Gas
Dodecyl benzene	.58	79.6	14.8	5.6	unkn	unkn	0^c	1^c	0^c	1	<<1 mm
Trichloroethylene	.53	47.8	40.3	11.9	.01	535	1^c	1^c	1^c	2	58 mm
Tetraethyl lead	.50	47.8	40.3	11.9	$high^c$	.10 skin	3	2	3	1	1 mm
Acetone cyanohydrin	.48	47.8	40.3	11.9	mdt $high^c$	mdt low^c	4	1	2	1	est. - 5 mm
Methyl ethyl ketone	.44	47.8	40.3	11.9	.005	590	2	2	4	2	71 mm
Methyl methacrylate	.40	0.1	85.4	14.5	.010	410	2	3	2	2	30 mm

Table A-5. DATA ON HAZARDOUS MATERIAL

Hazardous Material	Annual Output (tons x 10^6)	Percentage Transported by			Toxicity			Flamm	React	Volatility	
		.0028	.0011	.019						Rating	Vapor Press 20°C
		Water	Rail	Truck	$\frac{1}{\text{TLV (ppm)}}$	TLV mg/m^3	NFPA Rating				
Sulfuric acid (fumes)	57.5	46.1	32.3	21.4	mdt high ^{c}	1	3	0	3^c	1	<< 1 mm
LPG (see propane)					(.001)	(1800)	0^c	4^c	0^c	4	Gas
Ammonia	26.80	42.7	47.9	9.2	*.04	*18	3	1	0	4	Gas
Nitric acid (fumes)	12.50	46.1	32.3	21.4	.50	5	2	1	0	1	
Benzene	8.50	79.6	14.8	5.6	.04	80	2	3	0	2	76 mm
Ethylene dichloride	5.80	47.8	40.3	11.9	.02	200	2	3	0	3	172 mm
Toluene	5.80	79.6	14.8	5.6	.005	750	2	3	0	2	21 mm
Styrene	4.85	47.8	40.3	11.9	.01	420	2	3	2	1	5.2 mm
Ethyl benzene	4.80	79.6	14.8	5.6	.01	435	2	3	0	1	7 mm
Methyl alcohol	4.60	8.6	86.2	24.8	.005	260	2^c	3	1^c	2	92 mm
Formaldehyde	4.35	47.8	40.3	11.9	*.50	*3	2	2	0	4	Gas
Vinyl chloride	4.30	47.8	40.3	11.9	*.005	*770	2	4	1	4	Gas
Hydrogen chloride	4.06	1.1	85.7	12.9	.20	7	3	0	0	4	Gas
Propane	3.90	47.8	40.3	11.9	.001	1800	0^c	4^c	0^c	4	Gas
Xylenes (Xylols)	3.90	79.6	14.8	5.6	.01	435	2	3	0	1	6 mm
Ethylene oxide	3.78	47.8	40.3	11.9	.02	90	2	4	3	4	Gas
Butadiene (inhibited)	3.20	47.8	40.3	11.9	.001	2200	2	4	2	4	Gas
Ethyl alcohol (Ethanol)	2.40	8.6	66.2	24.8	.001	1900	1^c	3^c	1^c	2	43 mm
Isopropyl alcohol (isopropanol)	2.10	8.6	66.2	24.8	.0025	980	1^c	3^c	1^c	2	33 mm
Cyclohexane	2.00	79.6	14.8	5.6	.0033	1050	1^c	3^c	0	2	74 mm
Chlorine	1.96	9.8	76.4	13.7	1.0	3	3	0	1	4	Gas
Acetic anhydride	1.70	0.1	85.4	14.5	.20	20	2	2	2	1	3.3 mm
Phenol	1.70	79.6	14.8	5.6	skin .20	19	3	2	0	1	< 1 mm
Acetaldehyde	1.70	47.8	40.3	11.9	.05	360	2	4	2	3	755 mm

Table A-5. DATA ON HAZARDOUS MATERIAL (Continued)

Hazardous Material	Annual Output (tons x 10^6).	Percentage Transported by			Toxicity			Flamm	React	Volatility	
		.0028	.0011	.019	TLV (ppm)[1]	TLV mg/m^3	NFPA Rating *			Rating	Vapor Press 20°C
		Water	Rail	Truck							
Aniline	.39	79.6	14.8	5.6	skin 0.20	19	3	2	0	1	< 1 mm
Insecticides (Parathion), etc.	.35	7.2	80.7	11.8		0.1	(4)	(1)	(0)	1	< 1 mm
Butyl alcohol	.33	8.6	66.2	24.8	.010	300	1^c	3^c	1^c	1	5.5 mm
Dichloro difluoromethane	.30	47.8	40.3	11.9	.001	4950	0^c	0^c	0^c	4	Gas
Hydrogen cyanide	.30	1.1	85.7	12.9	skin .10	11	4	4	2	3	620 mm
Trichloro - ethane	.29	47.8	40.3	11.9	skin .10	(45)	1^c	1^c	0^c	2	18 mm
Ethyl chloride	.26	47.8	40.3	11.9	.001	2600	2	4	0	4	Gas
Perchloric acid	.23	1.1	85.7	12.9	mdt high^c	mdt low^c	3	0	3	1	1 mm
Chlorosulfonic acid	.23	1.1	85.7	12.9	mdt high^c	1	3	0	2	1	< 1 mm
Sulfur dioxide	.18	1.1	85.7	12.9	.20	13	3	0	0	3	Gas

* Change intended for 1970

c Estimated from other reference

( )Estimate for typical compound of family

Table A-5. DATA ON HAZARDOUS MATERIAL (Continued)

A.2 Techniques for Chemical Detection

The following pages are selected reproductions from the bibliography by Walter E. Ruch* on "Chemical Detection of Gaseous Pollution." This publication is generally held to be authoritative on the subject. It will be noted, however, that detection techniques are often not specific for a particular chemical to the exclusion of all others. Interferences are a problem especially in the case of rapid detection techniques.

Not listed in this section are optical techniques that are in limited use. One such technique utilizes the principle of Frustrated Multiple Internal Reflection (FMIR) or Attenuated Total Reflection (ATR), in which an infrared beam is passed through a prism surrounded by contaminant and the emerging beam is analyzed spectrographically. The FMIR technique is particularly useful in identifying organophosphates, the signatures of which all show a spike in 9.2 to 9.4 micron band. Many pesticides are in this family of compounds.

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*See Appendix B, Reference 4.

Aldehydes

1—USE OF SPOT TESTS FOR THE EXAMINATION OF PHARMACEUTICALS. VIII. DETECTION OF ALDEHYDE WITH A PERMANENT TEST PAPER

Frehden, O. and K. Fuerst. Mikrochemie **26**, 39-40 (1939); CA **33**, 3526 (1939).

The test paper is prepared by dissolving 0.8 g of malachite green and 3 g sodium sulfite, to this is added 3 more grams of sulfite and the resulting solution is filtered. Strips of filter paper are dipped into the solution and air dried. When an aldehyde contacts the impregnated paper malachite green is reformed. In order for the test to be successful the test solution used must be neutral and the test paper white. Approximately 20 aldehydes were tested by this method and concentration in the range of 0.02 to 0.3 could be detected.

7—SPOT TEST DETECTION AND COLORIMETRIC DETERMINATION OF ALIPHATIC ALDEHYDES WITH 2-HYDRAZINOBENZOTHIAZOLE. APPLICATION TO AIR POLLUTION

Sawicki, Eugene and Thomas R. Hauser. Anal. Chem. **32**, 1434-1436 (1960).

All the modifications of a versatile new procedure for the detection and determination of alipathic aldehydes are especially sensitive for formaldehyde. On the spot plate 0.01 μg of formaldehyde, 0.3 μg of acetaldehyde, and 0.3 μg of propionaldehyde can be detected; on paper 0.05 μg of formaldehyde, 1 μg of acetaldehyde, and 1 μg of propionaldehyde are detectable, and with proper standards, the amount of formaldehyde can be estimated. A tube containing silica gel impregnated with 2-hydrazinobenzothiazole solution can detect or estimate formaldehyde in the air or in auto exhaust gases. In all the modifications a brilliant blue color is easily seen.

5—DETECTION AND ESTIMATION OF LOW CONCENTRATIONS OF ALDEHYDE IN AIR

Hughes, Ernest E. and Sharon G. Lias. Anal. Chem. **32**, 707-708 (1960).

Aldehyde is adsorbed from an air stream on purified silica gel, which is contained in glass tubes 5 mm in internal diameter and 7 cm long. The tubes, filled about half full, are plugged with a wad of cotton at the outlet end only. The air sample is drawn with a syringe or pump through the gel with the tube vertical, after which the remainder of the tube is filled carefully with clean silica gel and closed with a second cotton plug. The gel added after exposure filters out the dark oxidation products of the developing reagent, which interfere with the color detection. The tube is dipped into developing reagent (saturated solution of *p*-phenylenediamine in water, mixed with 3% hydrogen peroxide in the ratio of 1:2 just before use) inlet end down. A dark band from impurities in the reagent appears at the inlet end of the tube, but adlehyde catalyzes oxidation of the p-phenylenediamine and produces a second dark band, colored from pale purple-brown to deep purple-brown or black, at the boundary of the two layers of gel, the depth of color on the gel being measured by the quantity of aldehyde adsorbed. Standard tubes can be prepared. As little as 0.0001 ppm can be detected in less than 10 liters of sample, with a flow rate as high as 0.7 liter per minute. Nitriles, aldehyde ammonia, oximes, and aldehyde bisulfite compounds interfere; ketones do not. Pure gum rubber tubing should be used for connections in the apparatus, because certain kinds of plastic tubing contain detectable quantities of aldehyde. Add. Ref.: IHD **24**, 596 (1960).

Aromatic Hydrocarbons

1—METHODS FOR THE DETECTION OF TOXIC GASES IN INDUSTRY. BENZENE VAPOR

Anon. Dept. of Scientific and Industrial Research, London, England. Leaflet No. 4 (1938) 7 pp.; Ibid., 2nd Edition (1955) 5 pp.

Benzene produces an orange-brown color with formaldehyde-sulfuric acid reagent. The reagent is prepared by adding 0.5 ml of 40% formaldehyde to a bubbler and diluting to 10 ml with concentrated sulfuric acid. Air is bubbled through the solution with a hand pump and the color formed is compared with that of standards made from sodium nitroprusside. With 18 strokes the sensitivity is 1 part in 10,000. Naphthas, toluene, and xylene react only qualitatively. Naphthalene interferes by producing a black film on the surface of the reagent. Thiophene and unsaturated hydrocarbons also interfere, but can be detected by bubbling the air through sulfuric acid alone. Add. Refs.: CA **33**, 4159 (1939); IHD **20**, 1066 (1956).

9—GAS ANALYSIS BY MEANS OF GAS DETECTORS. II. RAPID METHOD FOR THE DETERMINATION OF THE MINUTE QUANTITY OF BENZENE IN AIR

Kobayashi, Yoshitaka. J. Chem. Soc. Japan, Ind. Chem. Sect. **55**, 544-546 (1952); CA **48**, 3852 (1954).

The author describes a method for the determination of benzene in air. A glass detector tube is filled with silica gel impregnated with a solution of sulfuric acid and formadlehyde. The benzene concentration is determined by the length of stain produced. The average error in the determination was found to be 5%. Add. Ref.: IHD **18**, 561 (1954).

13—RAPID METHOD OF BENZENE OR BENZENE HOMOLOGS DETERMINATION WITH THE USE OF INDICATORS

Yavorovskaya, S. F. Khim. Prom. **1956**, 366-367; CA **51**, 3371 (1957).

The author describes a chromatographic method for the determination of benzene and its homologs. Silica gel is impregnated with sulfuric acid and formaldehyde. Air is aspirated through the column; the color produced is orange yellow which changes after 2 to 3 minutes to a violet, gray, brown and violet-brown depending upon the homolog present. The sample column is compared with standards prepared by vaporizing known amounts of benzene, toluene, or xylene in acetone. The results obtained with this method differ little from the results of tests conducted by nitration or catalytic combustion.

20—DETERMINATION OF BENZENE IN THE PRESENCE OF ITS HOMOLOGS IN THE ATMOSPHERE

Vlasak, Rudolf. Pracovni lekarstvi **11**, 418-422 (1949); CA **54**, 12440 (1960).

A description of a method for the determination of benzene, where the air sample is nitrated and the resulting nitrogen dioxide compound reacted with methyl ethyl ketone in pyridine to produce a violet color, is given. Benzene is adsorbed on silica gel and desorbed with a stream of nitrogen at 100-110°. Adequate sensitivity is achieved.

Ammonia

3—A NEW AND SENSITIVE TEST FOR AMMONIA

Makris, Konstantin G. Z. anal. Chem. **81**, 212-214 (1930); CA **24**, 4731 (1930).

A freshly prepared mixture of 2 cc of 20% silver nitrate solution mixed with 1 cc of a 5% tannin solution provides a sensitive reagent for the detection of ammonia. One drop of the mixture is placed on a watch glass and 0.1 cc of the test solution is contacted with the reagent. If ammonia is present a silver ring will appear rapidly. An alternate procedure is to impregnate a wad of cotton with the reagent and bring it close to a solution containing ammonia. Heat the ammonia containing solution and a silver deposit will form on the cotton if at least .005 g of ammonia is present.

6—DETECTION OF AMMONIA IN AIR

Korenman, I. M. Z. anal. Chem. **90**, 115-118 (1932).

Aniline, sulfanilic acid, benzidine, phenylhydrazine, "ursol D.W.", "ursol D. S.", alhpa- and beta-naphthylamine, para-aminobenzearsonic acid salt and p-nitraniline were diazotized by sodium nitrite and hydrochloric acid. The products formed were sensitive agents for the detection of ammonia. Filter paper impregnated with one of the diazotized amines will detect fractions of a milligram of ammonia. Add. Ref.: CA **27**, 43 (1933).

Chlorinated Hydrocarbons

2—AN APPARATUS FOR THE DETECTION AND ESTIMATION OF CHLORINATED HYDROCARBON VAPORS IN AIR

Timmis, L. B. J. Soc. Chem. Ind. **63**, 380-382 (1944); CA **39**, 1786 (1945).

A test paper is attached to the front of a glass tube containing a centrally located filament which can be heated. The sample is passed over the heated filament to decompose the chlorinated hydrocarbon into products which yield a color on the test paper.

Acetone

1—RAPID DETERMINATION OF ACETONE IN AIR

Bulycheva, A. I. Gigiena i Sanit. **13**, 30 (1948); CA **43**, 8974 (1949).

The author describes a colorimetric determination for acetone which is based upon the reaction with hydroxylamine hydrochloride and bromophenol blue. The error is less than 16% using 10 to 15 minute air samples.

2–GAS ANALYSIS BY MEANS OF DETECTOR TUBES. IV. RAPID METHOD FOR THE DETERMINATION OF ACETONE VAPOR

Kobayashi, Yoshitaka. J. Chem. Soc. Japan, Ind. Chem. Sect. **56**, 174-175 (1953); CA **48**, 9271 (1954).

The detector tube for the determination consists of a column of 40 to 60 mesh silica-gel granules which is impregnated with a dichromate solution made acid with sulfuric acid. In the presence of acetone the orange yellow detection column changes to a chocolate color. The concentration of acetone is determined by measuring the length of the chocolate stain. Calibration factors are provided for various temperatures at which the determinations are made. Among the interferences found are methyl alcohol, ethyl alcohol, benzene, ether, sulfur dioxide, hydrogen sulfide.

Acrylonitrile

1–DETERMINATION OF ACRYLONITRILE VAPOR MEANS OF DETECTOR TUBES

Kobayashi, Yoshitaka. Yuki Gosei Kagaku Kyokai **14**, 673-675 (1956); CA **51**, 7240 (1957).

The author describes the preparation of an indicating tu for the determination of acrylonitrile. The reagent cons of silica gel coated with a solution of sulfuric acid, chror acid and water sealed in a glass tube. To carry out determination the tips are broken from the tube and 1 cc of air are aspirated through it in 200 minutes. T concentration of acrylonitrile is determined by the len of the dark green colored stain produced. The useful rang is 1 to 120 mg of acrylonitrile per 1000 cc of air. Oxygen, nitrogen, carbon dioxide, ethane, methane, carbon tetrachloride, and hydrogen cyanide do not interfere, but reducing substances such as hydrogen sulfide, sulfur dioxide, propane, ethylene, alcohols, aldehydes, and ketones color the silica gel and interfere with the result. When acetylene is present in air, the silica gel is colored light brown but causes no hindrance.

Chlorine

4—FREE CHLORINE IN AIR. A COLORIMERIC METHOD FOR ITS ESTIMATION

Porter, Lyman E. Ind. Eng. Chem. **18,** 730-731 (1926).

A rapid method for estimating free chlorine in air uses a reagent of 1 g of o-tolidine dissolved in 100 cc of concentrated hydrochloric acid and diluted to 1 liter. Pass a measured volume of the air to be tested through 10 cc of the reagent in an absorption tube. Transfer quantitatively to a Nessler tube, dilute to mark, let stand 2 minutes, then compare the color with those in a set of permanent standards made from copper sulfate and potassium dichromate solutions. Add. Ref.: CA **20,** 2800 (1926).

Ethylene Oxide

7—RAPID METHOD FOR THE DETERMINATION OF ETHYLENE OXIDE VAPOR BY MEANS OF A DETECTOR TUBE

Kitagawa, Tetsuzo and Yoshitaka Kobayashi. J. Chem. Soc. Japan, Ind. Chem. Sect. **58,** 514-517 (1955); CA **49,** 5634 (1955).

The authors describe a detector tube for the analysis of ethylene oxide. The detector tube consists of a glass tube (2 mm in diameter) filled with 0.2 g of silica-gel granules on which potassium dichromate acidified by sulfuric acid has been adsorbed and dried. The working curves to interpolate the ethylene oxide concentration from measuring (a) color changed length of detecting column (from orange-yellow to dark yellow-green) after 100 cc of gas is allowed to flow at a rate of 1 cc per second, or (b) volume of gas needed to change the color up to a certain length of the detecting column. At the procedure (a), the calibration for temperature is carried out by a given diagram. The range of concentration of ethylene oxide to be analyzed with an accuracy of ± 5% is: (a) 0 to 4.0%; (b) 0.003 to 0.5%. Interfering materials include alcohols, aldehydes, diethyl ether, sulfur dioxide, hydrogen sulfide, acetone, benzene, aniline, petroleum, carbon disulfide, nitrous oxide, and hydrochloric acid.

Formaldehyde

7—THE DETERMINATION OF SMALL AMOUNTS OF FORMALDEHYDE IN AIR

Kersey, R. W., J. R. Maddocks, and T. E. Johnson. Analyst **65**, 203-206 (1940.)

The article details an application of Schryver's method (see above). Prepare a 1% phenylhydrazine hydrochloride solution by suspending 1 g of phenylhydrazine in about 5 ml of water, adding 2 ml of concentrated hydrochloric acid (sp. gr. 1.16) and diluting to about 80 ml. Filter and dilute the filtrate to 100 ml with water. An intense magenta color is formed when dilute solutions of formaldehyde phenylhydrazone are treated with potassium ferricyanide in presence of an excess of hydrochloric acid, the depth of color (between certain limts) being proportional to the concentration of formaldehyde present. The working range of the test is approximately 1 to 5 parts of formaldehyde per million of solution, although 0.5 ppm is detectable. Add. Ref.: CA **34**, 4016 (1940).

Hydrocarbons

1—COMPOSITION FOR THE DETECTION OF HYDROCARBONS

Grosskopf, Carl (to Otto H. Draeger). U. S. (Pat. No.) 2,800,460, July 23, 1957; CA **51**, 16212 (1957).

A carrier, preferably silica gel, is impregnated with selenious acid and charged with sulfud trioxide. The reagent, in contact with vaporous hydrocarbons, changes color from yellow to brown.

2—ANALYZING FOR HYDROCARBONS

Anon. Chem. and Eng. News **35**, No. 21, 82-83 (1957).

A simple field apparatus, which can be operated by untrained personnel, will determine in 5 minutes the concentration of aliphatic or alicyclic hydrocarbons in the range 0 to 5000 ppm, with a maximum error of ± 20%. A special calibration scale is fitted to a standard squeeze bulb assembly, a tube containing iodine pentoxide and 65% fuming sulfuric acid on silica gel is placed in the holder beside the scale, and an air sample is drawn through the tube with 1 squeeze of the bulb. The hydrocarbon concentration, read directly from the scale, is proportional to the length of the brown iodine stain in the tube. Olefins, aromatics, aldehydes, alcohols, and carbon monoxide do not interfere.

HYDROGEN CYANIDE

HYDROCYANIC ACID

31—A SENSITIVE, PORTABLE, SELF-CONTAINED PHOTOTUBE COLORIMETER FOR THE FIELD DETERMINATION OF CYANIDE IN AIR

Lester, David and Philip F. Ordung. J. Ind. Hyg. Toxicol. **26**, 197-200 (1944).

The colorimeter measures the change in light absorption of a methemoglobin solution in which a part of the methemoglobin is transformed to the cyanide derivative. Draw the cyanide-containing gas sample through the solution of methemoglobin with an aspirating pump; read the light absorption of the solution before and after passage of the gas. (See previous reference for preparation of the methemoglobin solution.) Add. Ref.: CA **38**, 5114 (1944).

32—A RAPID AND SIMPLE METHOD FOR MEASURING SMALL AMOUNTS OF CYANIDE GAS IN AIR

Robbie, W. A. and P. J. Leinfelder. J. Ind. Hyg. Toxicol. **27**, 136-139 (1945).

Bubble a known volume of the gas-air sample through a mixture of 3 parts of 0.005 M dibasic (hydrous) sodium phosphate and 1 part of a reagent made by adding 1 ml of 0.5% phenolphthalein in absolute ethanol to 99 ml of 0.01% copper sulfate (pentahydrate) solution. Add 1 part of 0.1% potassium hydroxide and after 1 minute measure the red color with a photoelectric colorimeter at 550 mu. Calculate the amount of hydrogen cyanide in the sample from a curve of readings of standard potassium cyanide solutions. The method is rapid, simple, and sensitive to 1 part of hydrogen cyanide in 50,000,000 reproducibly, and 1 gamma in 20 ml with a maximum error of 5%. Free halogen gases, hydrogen sulfide, and phenol interfere. The sample must not contain a higher concentration of hydrogen cyanide than the reagent can handle. Add. Ref.: CA **39**, 4813 (1945).

34—RAPID METHOD FOR THE DETERMINATION OF HYDROCYANIC ACID IN AIR

Fomicheva, N. I. Zavodskaya Lab **13**, 172-174 (1947) (in Russian); CA **42**, 1151 (1948).

A reagent for the determination of hydrogen cyanide is prepared by mixing equal volumes of (A) a solution of 0.2 g benzidine in 100 ml water, heated with a few drops of acetic acid, and (B) a 0.3% solution of copper acetate. 20 grams of silica gel are stirred into the liquid and then dried. The reagent should be used within a few hours after preparation. Owing to rapid change of the color, comparison standards are preferably prepared in water colors on paper; air should be sucked through the silica gel at a rate of 600-700 ml per minute. The method is suitable for the determination of 0.0004 to 0.05 mg hydrogen cyanide per liter.

49—A FIELD METHOD FOR THE RAPID DETERMINATION OF HYDROGEN CYANIDE IN AIR

Dixon, B. E., G. C. Hands, and A. F. F. Bartlett. Analyst **83**, 199-202 (1958).

A field test for determining specifically small amounts of hydrogen cyanide in industrial atmospheres is based on the formation of permanent Prussian blue stains on 4" by 3" Whatman No. 50 filter paper strips impregnated with 10% aqueous ferrous sulfate and 20% aqueous sodium hydroxide, then dried. Draw the test air through the paper at not more than 6 ml per second until 360 ml have been drawn, then immerse the paper in 30% sulfuric acid in a dish. Hydrogen cyanide turns the paper blue in from 30 seconds to 1 minute. Determine the amount of hydrogen cyanide by comparing the test stain with the stains on a standard stain chart. The test can detect up to about 500 ppm and is sensitive to slightly less than 1 ppm with an error of plus or minus 10% to 20%. Properly prepared and stored test papers remain active for about 10 months. Add. Refs.: IHD **22**, 1175 (1958); AA **5**, 3175 (1958); CA **52**, 13527 (1958).

Hydrogen Sulfide

5—A DETECTOR FOR LOW CONCENTRATIONS OF HYDROGEN SULFIDE

Littlefield, J. B., W. P. Yant, and L. B. Berger. Bur. Mines, Rept. of Investigations No. 3276, 13 pp (1935); CA **29**, 5382 (1935).

A rubber bulb or hand pump aspirates air to be tested for hydrogen sulfide through sensitized granules in a glass tube. Granules of activated aluminum trioxide (20-24 mesh) coated with silver cyanide or lead acetate satisfactorily estimated 0.0025 to +0.05% by volume of hydrogen sulfide, at temperatures from −22 to +25°. Tubes filled with silver cyanide-coated granules retained their sensitivity and usefulness after 18 months' storage. The detector indicates the amount of hydrogen sulfide either by the length of the dark stain produced by a constant sample volume, or by the volume of sample required to produce a standard length stain. Carbon monoxide, carbon dioxide, sulfur dioxide, chlorine, hydrogen chloride, natural gas, gasoline, benzene, ethyl and methyl alcohols do not react. Mercaptans interfere.

28—RAPID METHOD FOR DETERMINING HYDROGEN SULFIDE IN AIR

Verokhobin, I. G. and E. D. Filyanskaya. Zavodskaya Lab. **14**, 106-107 (1948); CA **43**, 971 (1949).

The authors describe an apparatus for the determination of hydrogen sulfide in air. The apparatus consists of a 100 ml capacity pump with a scale graduated in mg hydrogen sulfiide per liter. Glass tubes filled with porcelain particles treated with a 10% solution of lead acetate in 1.0% acetic acid are used. Hydrogen sulfide concentrations from 0.05-0.3 mg per liter can be detected within ±3-4% of the true value.

Methanol

1—A SIMPLE AND RELIABLE METHOD FOR THE DETERMINATION OF METHYL ALCOHOL AND FORMALDEHYDE IN AIR

Ackerbauer, C. F. and R. J. Lebowich. J. Lab. Clin. Med. **28**, 373-377 (1942).

Draw air through a series of 4 bubblers containing, in the first bubbler, 75 ml of 1% phosphoric acid and 75 ml of 2% barium chloride, mixed; in the second bubbler, 200 ml of an alkaline solution of potassium permanganate, which removes by oxidation all of the methanol; in the third, 225 ml of modified Schiff's reagent of Wright; and in the fourth bubbler (which may be eliminated in the perfield) 200 ml of 2 N sodium bisulfite. Decolorize the permanganate in the second bubbler with oxalic-sulfuric acid mixture, and add Schiff's reagent. Compare the color with those in a set of standards, either visually, or, preferably, in a Hellige colorimeter. Add. Ref. CA **37**, 6592 (1943).

Propane

1—DETERMINATION OF SOLVENT VAPORS IN AIR. V. PROPANE

Kobayashi, Yoshitaka. J. Soc. Org. Synthet. Chem., Japan **12**, 360-363 (1954); CA **51**, 952 (1957).

Silica gel impregnated with a mixture of sulfuric acid and chromic acid was used for the determination of solvent vapors. The effective range is 0.1 to 10.0 per cent.

APPENDIX B

"READY REFERENCE" SHELF

Recommended Reference Sources on Accidental Episodes

(See also: Appendix F)

1. Patty, F. A., (Ed.) Industrial Hygiene and Toxicology, Volume 1, Second Edition. Interscience Publishers, Inc., New York, 1958. Volume 2, Second Edition. Interscience Publishers, Inc., New York, 1962.

2. Fairhall, L. T., Industrial Toxicology, Second Edition. The Williams and Wilkins Company, Baltimore, 1957.

3. Browning, Ethel. Toxicity and Metabolism of Industrial Solvents. American Elsevier Publishing Company, Inc., New York, 1965.

4. Ruch, W. E., (Ed.) Chemical Detection of Gaseous Pollutants, 1966; or Quantitative Analysis of Gaseous Pollutants, 1970. Ann Arbor Science Publishers, Inc., Ann Arbor.

5. Gleason, M. N., Gosselin, R. E. and Hodge, H. C. Clinical Toxicology of Commercial Products. The Williams and Wilkins Company, Baltimore, 1957.

6. Chemical Safety Data Sheets. Manufacturing Chemists' Associations, Inc., Washington, D. C.

7. Sax, N. I. Dangerous Properties of Industrial Materials. Reinhold Book Corporation, New York, N. Y.; third edition, 1968.

8. Hazardous Chemicals Data 1968; National Fire Protection Association, Boston, Mass. 02110, NFPA No. 49.

9. Manual of Hazardous Chemical Reactions 1968; National Fire Protection Association, Boston, Mass. 02110, Third Edition, NFPA No. 491M.

10. Dangerous Articles Emergency Guide: Recommended Good Practice for Handling Fires or Spills Involving Explosives and Other Dangerous Articles. Bureau of Explosives, Association of American Railroads, New York, N.Y.; B. E. Pamphlet No. 7A, March 1970.

11. Fire Hazard Properties of Flammable Liquids, Gases, Volatile Solids, 1965. National Fire Protection Association, Boston, Mass. 02110; NFPA No. 325M.

12. Johns, W. E., (Director) Dangerous Article Handling: A Guide for the Proper Handling and Transportation of Hazardous Material by Motor Carrier. American Trucking Associations, Inc., Washington, D. C. 20036, Revision January 1970.

13. MCA Chem-Card Manual: A Compilation of Guides for the Safe Handling of Chemicals Involved in Highway Emergencies. Manufacturing Chemists' Association, Washington, D. C. 20009, through August 1965.

14. Planning Emergency Operations for Disasters in Small Communities. Manual scheduled for release in 1971 by Office of Civil Defense, Department of the Army, U. S. Department of Defense, Washington, D. C.

15. Kahn, R. B., (Ed.) Directory of Industrial Mutual Aid Associations, Directorate of Procurement and Production (MCPM), Headquarters, Air Force Logistics Command, U. S. Air Force, Wright-Patterson AFB, Ohio, April 1961 (revision in preparation).

16. Turner, B. D., Workbook of Atmospheric Dispersion Estimates, U. S. Department of Health, Education and Welfare, National Air Pollution Control Administration, Public Health Service Publication No. 999-AP-26, Revised 1969.

PART II.

CONTINGENCY ACTION GUIDE FOR LOCAL COMMUNITIES

5. CONTINGENCY PLAN FOR COMMUNITY ACTION

5.1 CONTINGENCY PLAN CONCEPT

The preceding discussion in Part I, which is focused upon the role of an Air Pollution Control Agency in response to accidental episodes, has noted that action is most effective when coordinated by a community-wide Contingency Plan. In Part II of this manual, the elements of a Contingency Plan are presented. The manual should provide guidelines to communities that intend to establish a Contingency Plan tailored to local needs.

A comprehensive Contingency Plan is the key element for advance preparation. It should specify who is to be alerted and in what sequence, how communications are handled, how the public is notified and if necessary evacuated, and when to terminate the emergency. It should describe the particular kind of event for which it is designed. (The definition of accidental episode given in Sec. 1.1 may serve this purpose.) This does not preclude availability of participating teams and individuals for other kinds of emergencies. On the contrary, a number of response teams or elements thereof are geared for action in all kinds of natural and man-made disasters that are covered by a general Disaster and Civil Defense Plan. Indeed, the Accidental Episode Contingency Plan may be but one section of the general Disaster Plan in accordance with the Disaster Relief Act of 1970.

5.2 GLOSSARY OF TERMS USED IN AN ACCIDENTAL EPISODE CONTINGENCY PLAN

- Accidental Episode

  An unexpected event during which contaminants are released into the air in quantities that are potentially hazardous to public health and welfare, as by transport over inhabited areas.

- Hazardous Material

  Chemical substances which, through intrinsic properties of toxicity, flammability, corrosivity, or explosivity, or combinations thereof, adversely react upon persons or property whether through contact or proximity.

- Contingency Plan

  A formal arrangement whereby the personnel and resources of numerous organizations, public and private, civil and military, are marshalled and employed in accordance with prescribed organization and procedures to minimize and counteract the effects of an accidental episode.

- Contingency Plan Organization

  The association formed by all participants of the Contingency Plan that have formally agreed to exercise designated functions through specified working relations and lines of command.

- Contingency Plan Administration

  The body of officers and assistants that is responsible for general policy and day-to-day execution of all executive, clerical, and fiscal management functions of the Contingency Plan Organization.

- Contingency Plan Advisory Board

  A group of authorities responsible for independent evaluation of Contingency Plan performance with recommendations on measures, including research, to improve effectiveness during accidental episodes.

- Contingency Response Team

  The total organized group of Contingency Plan participants who are under formal agreement jointly or severally to be available for prescribed operational or support duties in the event of an accidental episode. The Contingency Response Team consists of an Operations Team and a Support Team.

- Contingency Operations

  Actions executed at or near the site of an accidental episode in implementation of the Contingency Plan, and line functions and direction exercised from remote headquarters.

- Contingency Operations Team

  The organized group of Contingency Plan participants who are charged with expeditious travel to the accidental-episode scene and performance of assigned duties aimed at combatting the hazard to personal life and property; also, the headquarters personnel who are in communication with on-scene participants and provide line authority and direction.

- Mobile Source Team

  The Contingency Response Team element that specializes in containing, neutralizing, and disposing of hazardous material emanating from a carrier (rail, motor vehicle, or barge) during an accidental episode.

- Stationary Source Team

  The Contingency Response Team element that specializes in containing, neutralizing, and disposing of hazardous material emanating from a permanent installation (plant, storage facility, etc.) during an accidental episode.

- Team Captain

  The Mobile or Stationary Source Team member who directs and may participate in action taken on the source of emanating hazardous material.

- Contingency Support

  Furnishing of resources such as technical expertise, legal counsel, and special personnel, equipment and material to guide or facilitate action taken during an accidental episode.

- Contingency Support Team

  The organized group of Contingency Plan participants who perform functions described above under Contingency Support.

- Chief Operations Authority (COA)

  The person charged with the responsibility and delegated commensurate authority, including command of specified law enforcement units, for planning and directing the coordinated overall operations of all Contingency Plan participants, public and private.

- On-Scene Commander (OSC)

  The person charged with the responsibility and delegated commensurate authority for directing the overall operations of Contingency Operations Team members at the site of an accidental episode, and for alerting and if necessary directing the evacuation of inhabitants that are threatened by the spread of hazardous material.

- Operations Duty Officer

  The person responsible for receiving and validating reports of accidental episodes, and notifying the Chief Operations Authority and others as provided by this Plan.

- Warning Controller

  One of several Police and Fire Department personnel who assist the Operations Duty Officer through receipt and validation of accidental-episode reports and notification of others following declaration of an alert.

- Disaster Service Coordinator

  Official designated to serve as liaison for the On-Scene Commander and Chief Operations Authority to furnish or locate sources of emergency equipment or services as required.

- Emergency Operations Center (EOC)

  Operational headquarters for information gathering and analysis, decision-making, communications, public relations, determination and acquisition of resources needs, and general direction and coordination of activity in response to an accidental episode.

- Command Post

  A temporary site near the release point of hazardous material selected by the On-Scene Commander as a vantage point from which his operations are to be directed.

5.3 LEGAL AUTHORITY

In a preamble or similar section, the legal authority for setting up and implementing the Contingency Plan should be cited. Detailed verbiage is not required, only accurate references to enabling legislation, executive orders, ordinances, resolutions, rules and regulations. A complete set of relevant legal instruments should be on file at the cognizant Emergency Operations Center (EOC).

5.3.1 Federal Law

Pertinent Federal legislation includes the following:

- Disaster Relief Act, Dec. 31, 1970; PL 91-606, and provisions of precedent laws, PL 89-769 and PL 81-875.

- Occupational Safety and Health (William-Steiger) Act of 1970; PL 91-596.

- Water Quality Improvement Act of 1970, PL 91-84.

- Clean Air Act, amendments of 1970, PL 91-604. See footnote, p. 1-5 on requirement for internal Emergency Action Plans for all stationary sources emitting 100 tons or more of pollutant.

- National Contingency Plan, PL 91-224, June 2, 1970.

5.3.2 Sample Cooperative Agreement to Establish the Accidental-Episode Contingency Plan Organization

THIS AGREEMENT by and between the undersigned Member agencies, and acknowledged by other signatory organizations, will establish Contingency Operating and Supporting Organizations for the coordination of activities to effectively secure, contain and abate disastrous releases of airborne hazardous materials in and about the communities of (- - - specify - - -).

WITNESSETH: Each of the parties hereto has interest, authority and/or responsibility concerning the effects of a massive release of hazardous chemicals in and about (- - - specify - - -), and each desires to cooperate in the employment of the forces, equipment, material and expertise in their various establishments, districts, regions and agencies in the event of a release that threatens to constitute a disaster.

The land, districts or regions of the parties hereto are concurrent, adjacent or contiguous so that cooperative action in combatting an accidental episode is feasible, and the jurisdiction and authority of some of the parties over certain areas is concurrent.

In the interest of the safety and well-being of the citizens of these jurisdictions it is the policy of the parties hereto and of their governing bodies to conclude such agreements whenever practicable, and it is mutually deemed sound, desirable, practicable and beneficial for the parties to this agreement to act in cooperation with one another in accordance with these terms.

THEREFORE BE IT AGREED THAT:

1. Whenever an uncontrolled release of airborne hazardous material occurs in and about the area of reference such that there is created or threatened a widespread hazard to human life, natural resources, or

public or private property, each of the parties hereto will proceed in accordance with the "Accidental-Episode Contingency Plan for (- - - specify - - -)" attached hereto.

2. In taking coordinated or cooperative action in accordance with the Plan, the parties assume no responsibility for failure of equipment or personnel in any particular instance where action is taken.

3. Unless funding arrangements have been stipulated between parties, the costs incurred by a party in responding to any actual or potential disaster for or on behalf of another party shall be borne by the responding party.

4. The obligations of the parties hereto shall be subject to statutory limitations on their authority and the availability of funds, personnel, equipment and material.

5. The organizations, agencies or forces of the parties to this agreement are invited and encouraged, on a reciprocal basis, to exchange information and to witness, participate in, or jointly conduct tests and demonstrations of procedures and techniques for the development, application and use of products and equipment which may be employed in response to an airborne release of hazardous material.

6. Each of the parties hereto shall review this plan at least once each year. Suggested changes thereto or supplementary detailed plans and procedures of operations necessary to more effectively implement the purposes of this agreement shall be submitted to the Chief Operations Authority. Amendments or additions to the plan as recommended shall be circulated and become effective upon ratification by the signatory parties.

7. Member agencies party hereto shall assist in planning and conducting such exercises designed to test this Contingency Plan as the Chief Operations Authority may request. Other organizations signatory hereto shall cooperate in such exercises to the extent permitted by their regular duties and other obligations.

8. This agreement shall remain in full force and effect until cancelled by mutual agreement of the parties hereto or by written notice by one party to the other parties, giving thirty (30) days notice of said cancellation.

9. This agreement may be executed in any number of counterparts and, for all practical purposes hereof, all such counterparts shall be considered as one agreement.

IN WITNESS WHEREOF, the undersigned Member agencies have executed and are bound by this agreement subject to the provisions hereinabove; and the Associates signatory hereto hereby acknowledge this plan, approve its purposes and agree to distribute copies hereof to their respective members with the request that each member, or regional groups of members, prepare its or their local contingency plan, compatible herewith, and forward a copy thereof to the Chief Operations Authority on or before (- - - date - - -).

List of signatory organization follows, with date, signature and title of the representative for each organization.

5.4 ALERT STAGES

In order that the use of manpower and equipment be restricted to what is realistically required for effective countermeasures, several alert stages should be defined. The following are suggested:

Readiness	
First Stage Alert:	Minor release of hazardous material, minimal threat to persons.
Second Stage Alert:	Moderate release of hazardous material, positive threat to persons, evacuations required, material may require further identification.
Third Stage Alert:	Substantial release of hazardous material, some casualties reported, material highly toxic, flammable, or explosive, threat to persons imminent, wholesale evacuations required.

5.5 EMERGENCY OPERATIONS CENTER (EOC)

Coordination of responsive action through the Emergency Operations Center is basic to the effective implementation of a Contingency Plan. The Emergency Operations Center or EOC label may be used in a generic sense to designate the headquarters site, which in small communities may be nothing more than a desk or working area at the county sheriff's office. However, in medium or large size communities, say on the order of 100,000 population or more, the EOC should be a separate, clearly identified room that is otherwise not used for routine purposes. It should be equipped with a sufficient number of outlets, plugs, telephone lines, etc., to handle the full complement of communication and other gear required in a Third Stage Alert. It should have permanent wall maps of at least two scales, one that shows the entire jurisdictional area and surroundings, the other that shows enlargements of major inhabited areas. Special purpose maps should be available for posting to show population densities, topography, location of team members, facilities, and equipment, power networks, storm drains and sewers, water supply, etc. There should be an adequate supply of office and map-posting materials. See Section 5.5.3.

If a local EOC already exists in accordance with a general Disaster Plan or Civil Defense Plan, it will normally provide facilities for handling hazardous chemical events. If a local EOC does not exist, an effort should be made to establish one and provide it with adequate funds, staffing, and equipment to bring it to a state of readiness.

5.5.1 Location

The EOC should be situated in a building such as the following:

- Headquarters of the Police or Fire Department
- Headquarters of the agency that handles disaster or emergency services
- A government or community building that is accessible to key personnel 24 hours a day.

One or more alternate sites should also be designated, preferably at facilities that have telephone switchboards with several outside lines plus enough space for additional communications equipment. Examples include:

- Radio stations
- Hospitals, including prepositioned sites of Public Health Service Packaged Disaster Hospitals
- Motels

Proximity to the APC office could be useful but is not an important consideration as long as a reliable communications link exists between the EOC and the APC agency.

5.5.2 Communications

Adequate communications for emergency action may be provided with existing facilities. One practical approach is to make an inventory of all existing communications systems in the community, and develop a simple plan to tie in the EOC to these facilities without overloading them. The inventory should include telephone switchboards, radio base stations, mobile units (one and two-way) and portables ("walkie-talkies"), whether owned by government, businesses, or private citizens. Local broadcast stations (radio and TV), particularly those with emergency power resources, can provide extensive one-way emergency information to the public. Police, fire, and public works "emergency service" communications can be augmented with back-up from commercial or amateur radio systems. If existing facilities are inadequate, the Plan should provide for appropriate procurement.

5.5.3 Visual Aids

Within the EOC, maps, charts, and supplementary information should be prominently displayed on walls, counters, desk or table tops, etc. It is recommended that detailed and wide-area county and town maps be permanently mounted, with provision for removable or erasable clear plastic overlays. Grease pencils and colored pins, disks, arrows, or similar markers should be used to delineate the predicted and last reported hazard area (See Section 4.4) and the deployment of field manpower and equipment. Color coding will be found useful for keeping display information clear and simple.

Additional display material could include the following special purpose maps and charts provided with clear plastic overlays:

- Population distribution or densities
- Highlighted topographic features
- Locations of team members, facilities, and equipment
- Power networks
- Storm drains, sewers, water supply
- Evacuation routes
- Detailed duty roster at the scene, the EOC, and supporting agencies

Additional support documentation needs are discussed in Section 5.6.

5.5.4 Space Requirements

The EOC should be spacious enough to provide working space for a complement of three to eight assigned personnel plus accommodation for representatives of the news media. It should have adequate wall and floor space to house the visual aids described in 5.5.3.

5.6 SUPPORT DOCUMENTATION

In addition to items recommended for inclusion in the Contingency Plan, a variety of documents should be on hand for reference when and if needed. The following are examples.

5.6.1 Texts of Pertinent Legislation, Regulations, Executive Orders, etc.

Duplicate copies should be on file at the EOC and executive quarters of the Contingency Plan Organization (preferably, the office of the Executive Secretary; see 6.1.2.3), in addition to participating State and local government offices. Key personnel should become familiar with the content of these documents. Periodic review and discussion of their provisions are recommended.

5.6.2 Disaster Manuals

Existing manuals for civil defense and general disaster contingencies are useful information sources on:

- Organizations, resources, and operational procedures established for response to related natural and man-made disasters
- The position of an Accidental Episode Contingency Plan within the general framework of emergency plans
- Facilities and manpower that could be shared

Manuals that may be available include:

- Disaster Manual, U. S. Public Health Service, Division of Health Mobilization (via Department of Health, Education and Welfare, Health Services and Mental Health Administration)
- Planning Emergency Operations for Disasters in Small Communities. Office of Civil Defense (may be available through regional or local office)

- Disaster Relief Manual (if available) for the city and/or county; the one for Los Angeles could serve as a model.

5.6.3 Mutual Aid Programs and Specialty Services

Mutual aid agreements and manuals of specialty services such as those provided by the Manufacturing Chemists Association, the Chlorine Institute, the National Fire Protection Association, the National Agricultural Chemists Association, and Mutual Aid Associations (see Appendix D) may provide input or serve as models for Contingency Plan development. Furthermore, where these programs operate in the Contingency Plan locality, they should be formally integrated into the plan by common agreement.

5.6.4 Glossary

A glossary of terms should be included among the supporting documents to ensure that the language used in the Contingency Plan and its implementation during an accidental episode mean the same thing to all participants. Illustrations and synonyms should be used to clarify terms that could have other meanings in common usage.

5.6.5 Forms

In addition to forms that are designed for general administrative use, such as contract, requisition, and purchase order forms, a supply of the following special forms is recommended:

- Model Alert Stage Proclamation forms
- Permit forms, to pass police lines
- Official forms to identify individuals and vehicles
- Activity log forms for staff and services
- Posters and signs to warn or direct the public ("Danger," "Keep Out," "Detour," etc.)

5.6.6 Technical Literature

At least two kinds of technical literature should be on hand:

- A "Ready Reference Shelf" on hazardous materials for immediate availability during an accidental episode (see Appendix B).

- Data manuals, indexes, and slide rules (see 5.6.7).

- Other relevant books, documents, reports, etc.

Duplicate reference shelves on hazardous materials should be on the premises of the EOC and the participating APC office. A recommended list of technical literature is given in Appendix F.

5.6.7 Slide Rules

Slide rules that provide quick access to information on hazardous chemicals are available at nominal cost. They are useful additions for the "Ready Reference Shelf." The following two are recommended:

(1) Chemical Safety Slide Rule, published by the National Safety Council, 425 North Michigan Avenue, Chicago, Illinois 60611.

Information provided on about 165 chemicals:

(1) Flash point
(2) Severity and type of hazard
(3) Precautions to take
(4) First aid
(5) Health hazards*
(6) Flammability*
(7) Reactivity (Instability) Hazards*
(8) Oral toxicity rating
(9) Action on skin
(10) References to detailed safety information

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* As defined by the National Fire Prevention Association (NFPA). See Appendix B, Reference 8

(2) Chemical Transportation Safety Index, published by the Railway Systems and Management Association, (RSMA) 181 Lake Shore Drive, Chicago, Ill. 60611.

Information provided on about 200 chemicals:

(1) Classification
(2) Degree of Risk
(3) Precautions
(4) Hazard to Life
(5) First Aid
(6) Danger of fire
(7) Control of fire
(8) Stability (reactivity with water)
(9) Clean-up precautions

Chemicals are listed by generic name. A 4-digit code is used to identify each chemical and to cross-reference synonyms and trade names, which are listed in a manual that comes as a companion piece to the slide rule within a vinyl cover. Some of the information provided by the manual on placards and labels for hazardous cargoes is reproduced here in Appendix E.

5.6.6 Inventory of Hazardous Chemicals

Every facility that manufactures, stores, utilizes, or transships bulk quantities of hazardous chemicals is required by State and/or Federal laws to meet Federal standards on occupational health and safety*. Provisions of the law cover standards for containers and carriers of the material, nozzles and valves for use in transfer, identifying labels and markers, handling procedures, protective equipment required, emergency first aid, procedures for response to accidental release, and methods for neutralization and disposal. Hence, the following additional documents are recommended for the EOC "Ready Reference Shelf":

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*PL 91-596, supra.

- A directory of all plants, laboratories, etc., within the jurisdictional area that have on their premises hazardous materials in sufficient quantity as to pose a threat to people on or off the premises if the material is accidentally released.

- An inventory of hazardous material listed alphabetically and cross-indexed with the directory above.

- A copy of the safety maintenance program for each facility, if available, including the internal Emergency Action Plan required by the Clean Air Act Amendments of 1970. See footnote, Section 1.2.

5.6.9 Standard Operating Procedures (SOP)

The manner in which team members interact to execute their responsibilities under the Contingency Plan is spelled out in documented Standard Operating Procedures (SOP). This subject is further treated in Section 7.

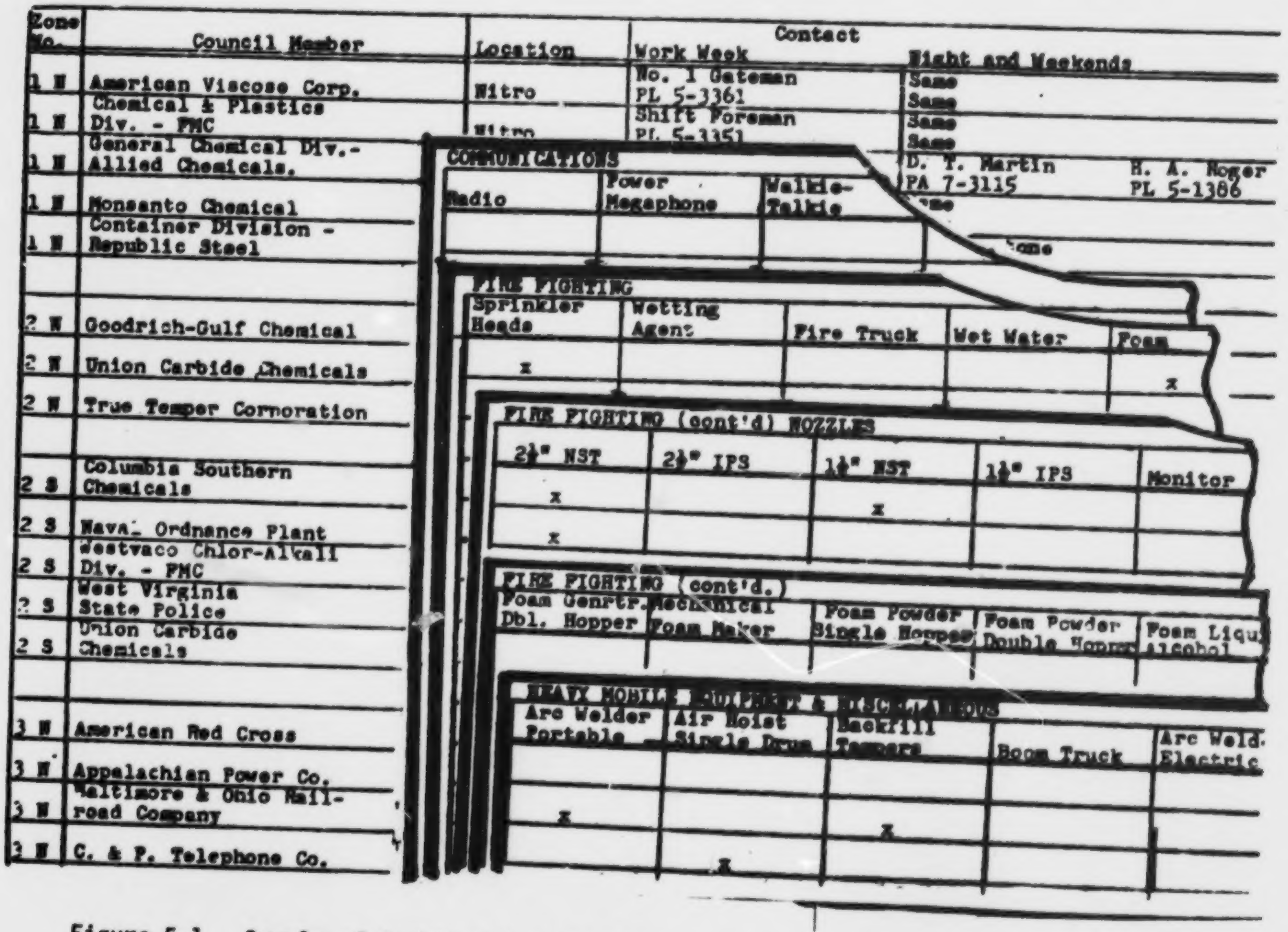
5.6.10 Directories

Two types of directories are recommended:

- "Working Directories," which are listings of people, services, and equipment that are to be contacted or called for at specified Alert stages in accordance with Standard Operating Procedures. Two forms of Working Directories are recommended:
    - A listing of team members and officials to be contacted in a given sequence or order of priority, in accordance with the Alert stage and developments at the accidental-episode site.
    - An alphabetical cross-index of services and equipment listing all team members from whom they are available.

Both Working Directories could be combined into a two-dimensional matrix by the use of overlays, foldouts, or half-page inserts, as in Figure 5-1.

- A "Master Directory," which is an alphabetical combined listing of all team members (agencies, companies, consultants, etc.) that includes names, addresses, and telephone numbers of key personnel and alternates during work week, night, and weekend duty hours; also available services and equipment for each member.



Zone No.	Council Member	Location	Contact		
			Work Week	Night and Weekends	
1 N	American Viscose Corp.	Nitro	No. 1 Gateman PL 5-3361	Same Same	
1 N	Chemical & Plastics Div. - FMC	Nitro	Shift Foreman PL 5-3351	Same Same	
1 N	General Chemical Div.- Allied Chemicals.			D. T. Martin PA 7-3115	H. A. Noger PL 5-1386
1 N	Monsanto Chemical			me	
1 N	Container Division - Republic Steel			ome	
2 N	Goodrich-Gulf Chemical				
2 N	Union Carbide Chemicals				
2 N	True Temper Corporation				
2 S	Columbia Southern Chemicals				
2 S	Naval Ordnance Plant				
2 S	Westvaco Chlor-Alkali Div. - FMC				
2 S	West Virginia State Police				
2 S	Union Carbide Chemicals				
3 N	American Red Cross				
3 N	Appalachian Power Co.				
3 N	Baltimore & Ohio Rail-road Company				
3 N	C. & P. Telephone Co.				

COMMUNICATIONS

Radio	Power Megaphone	Walkie-Talkie

FIRE FIGHTING

Sprinkler Heads	Wetting Agent	Fire Truck	Wet Water	Foam
x				x

FIRE FIGHTING (cont'd) NOZZLES

2½" NST	2½" IPS	1½" NST	1½" IPS	Monitor
x		x		
x				

FIRE FIGHTING (cont'd.)

Foam Genrtr. Dbl. Hopper	Mechanical Foam Maker	Foam Powder Single Hopper	Foam Powder Double Hopper	Foam Liqu alcohol

HEAVY MOBILE EQUIPMENT & MISCELLANEOUS

Arc Welder Portable	Air Hoist Single Drum	Backfill Tampers	Boom Truck	Arc Weld. Electric
x		x		
	x			

Figure 5-1. Sample of Combined Working Directory Showing Half-page Foldovers (Courtesy of Kanawha Valley Industrial Emergency Planning Council)

5.7 CHECK LISTS

Check lists are useful tools in emergency situations. They serve as reminders of all tasks to be performed, and thereby ensure that no essential task is omitted. In episode-prone localities their use should be made mandatory.

Check lists should be detailed, terse, and precise. They should be employed in a manner similar to the challenge and response of pilot and co-pilot in the cockpit of an aircraft.

Check lists adapted from the "Los Angeles County and Cities Disaster Relief Manual, 1970" have been incorporated into sections of this manual where applicable. As a check list in operational use, it may serve as a guide to other communities as they develop Contingency Plans.

5.7.1 Emergency Operations Center

Designate Emergency Operations Center site ____
Designate alternate EOC sites ____
Provide reliable land line communications ____
Arrange emergency radio communications ____
Designate initial personnel cadre staffing ____
Assign headquarters space, by function ____
Assign records and reports functions ____
Provide situation maps and charts ____
Provide EOC equipment, supplies and forms ____

5.7.2 Emergency Supplies and Assistance

Check, as Applicable

a. Disaster Procurement

Have on hand:

Complete, current commodity price list or index ____
Purchase order forms ____
Requisition forms ____
Standard contract forms ____

Check, as Applicable

Establish system to account for and report non-recurring, unbudgeted disaster and emergency costs as they occur (separate from normal day-to-day expenses) ____

b. Pre-Stock Emergency Supplies

Activity log forms, for staff and services ____

Model disaster proclamation forms ____

Official forms to identify individuals and vehicles ____

Permit forms, to pass police lines ____

Special purpose maps showing storm drains, sewers, water supply, etc. ____

Office supplies and map-posting materials ____

Posters and signs to warn or direct the public ("Danger," "Keep Out," "Detour," etc.) ____

c. Pre-Plan Additional Needs

Arrange prompt centralized release of information and instructions to the public and close cooperation with news media (radio, TV and newspapers) ____

Arrange photographic coverage to document the disaster situation and operations ____

Have current directory of local, state and Federal disaster relief resources and contacts. ____

Understand, coordinate and pre-plan emergency roles of the American Red Cross and other local private and public welfare agencies ____

Encourage school Districts to sign agreements with Red Cross authorizing emergency use of school facilities as mass care centers ____

Pre-plan emergency use of any other appropriate resources ____

Check, as Applicable

d. Mutual Aid and Other Assistance

Have copies of the following on hand:

Contingency Plan ____

General Disaster Manuals ____

Local Mutual Aid Agreements ____

Office of Emergency Preparedness (OEP) Circular 4000.5B, Natural Disaster Assistance Program ____

Insure that key personnel understand:

Roles and functions of agencies concerned ____

Principles of self-help and mutual aid ____

Sources of assistance ____

Mutual Aid to assist other jurisdictions ____

State and Federal assistance that generally is requested only when local resources are inadequate ____

6. CONTINGENCY PLAN IMPLEMENTATION: ORGANIZATION

Effective implementation of an Accidental Episode Contingency Plan requires the establishment of a Contingency Plan Organization and the adoption of Standard Operating Procedures for utilizing the available resources of the Organization and its component units. The Contingency Plan Organization is the total combination of agencies and individuals who exercise assigned participant roles in accordance with a functional structure that defines responsibilities, interrelations, and lines of command within the Contingency Plan.

The Contingency Plan Organization shown in Figure 6-1 is offered as a guide. An appropriate organizational structure should be tailored to the needs and resources of each community that establishes a local Contingency Plan. As shown, the total organization is comprised of the following functional groups.

- Officers
- Advisory Board
- Contingency Operations Team
- Contingency Support Team

The interrelation of these groups is shown schematically in Figure 6-2. Details on duties, responsibilities, and Standard Operating Procedures are the subjects of Chapters 6 and 7.

6.1 OFFICERS OF THE CONTINGENCY PLAN ORGANIZATION

6.1.1 Executive Authority

6.1.1.1 Governor

The Governor of the State (or Commonwealth) has ultimate responsibility for the protection of life and property of all individuals residing within or in transit through his jurisdiction. As such, he is

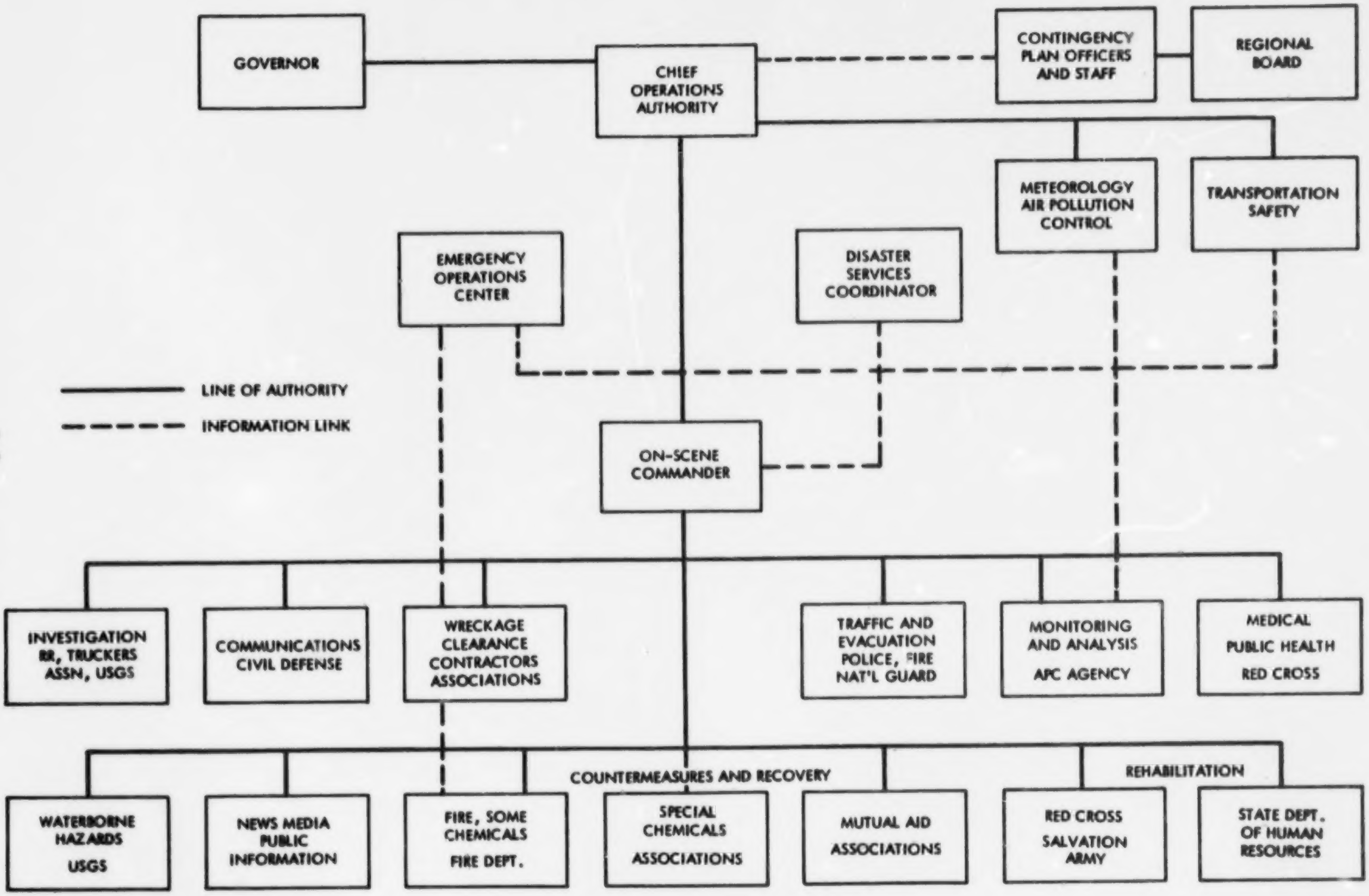

GOVERNOR
CHIEF OPERATIONS AUTHORITY
CONTINGENCY PLAN OFFICERS AND STAFF
REGIONAL BOARD
METEOROLOGY AIR POLLUTION CONTROL
TRANSPORTATION SAFETY
EMERGENCY OPERATIONS CENTER
DISASTER SERVICES COORDINATOR
LINE OF AUTHORITY
INFORMATION LINK
ON-SCENE COMMANDER
INVESTIGATION RR, TRUCKERS ASSN, USGS
COMMUNICATIONS CIVIL DEFENSE
WRECKAGE CLEARANCE CONTRACTORS ASSOCIATIONS
TRAFFIC AND EVACUATION POLICE, FIRE NAT'L GUARD
MONITORING AND ANALYSIS APC AGENCY
MEDICAL PUBLIC HEALTH RED CROSS
COUNTERMEASURES AND RECOVERY
REHABILITATION
WATERBORNE HAZARDS USGS
NEWS MEDIA PUBLIC INFORMATION
FIRE, SOME CHEMICALS FIRE DEPT.
SPECIAL CHEMICALS ASSOCIATIONS
MUTUAL AID ASSOCIATIONS
RED CROSS SALVATION ARMY
STATE DEPT. OF HUMAN RESOURCES

Figure 6-1. Model Contingency Plan Organization

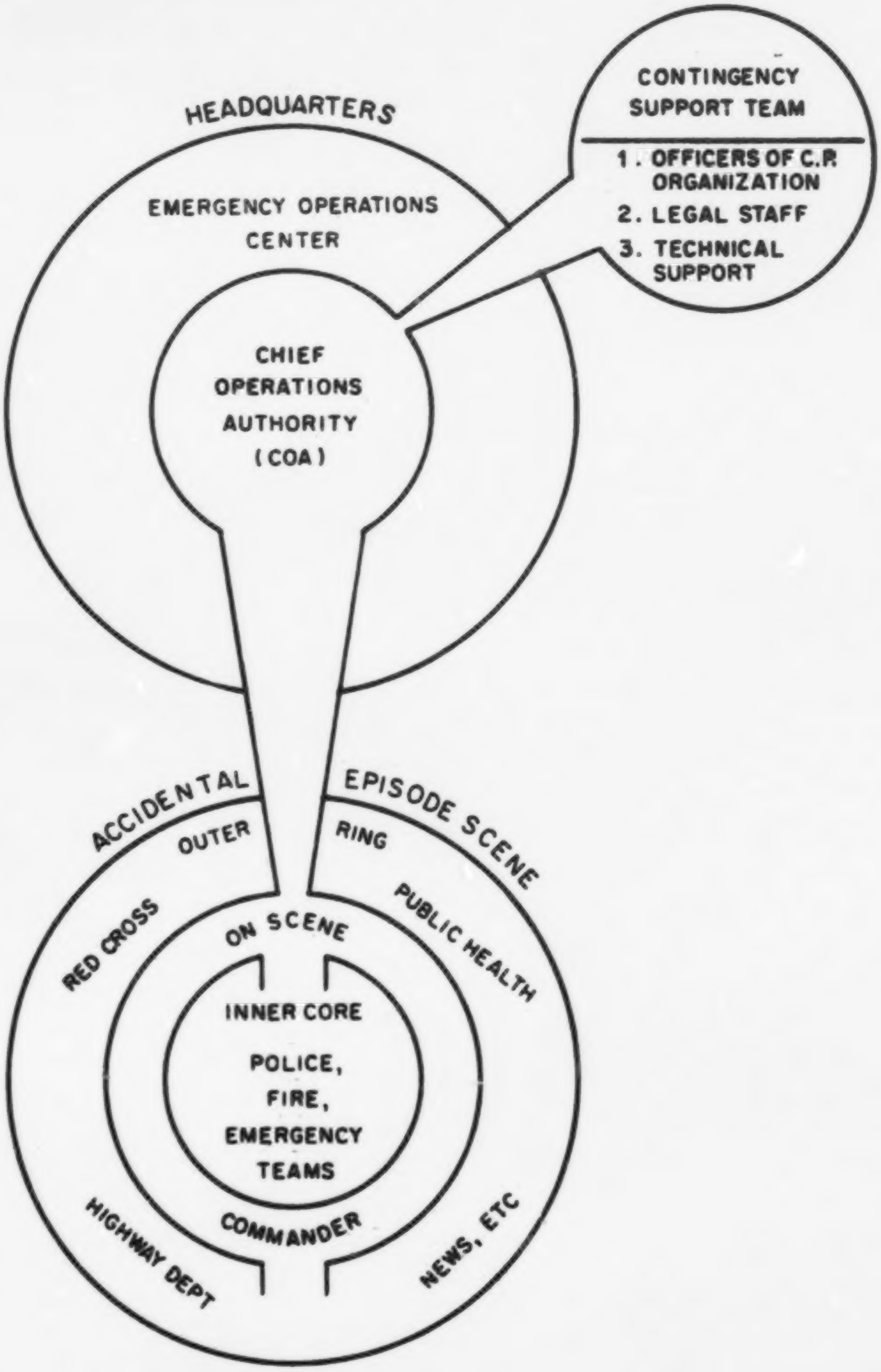

HEADQUARTERS
EMERGENCY OPERATIONS CENTER
CHIEF OPERATIONS AUTHORITY (COA)
CONTINGENCY SUPPORT TEAM
1. OFFICERS OF C.P. ORGANIZATION
2. LEGAL STAFF
3. TECHNICAL SUPPORT
ACCIDENTAL EPISODE SCENE
OUTER RING
RED CROSS
PUBLIC HEALTH
HIGHWAY DEPT
NEWS, ETC
ON SCENE COMMANDER
INNER CORE
POLICE, FIRE, EMERGENCY TEAMS

Figure 6-2. Schematic Representation of a Contingency Response Team

ex-officio Supreme Operations Authority for all Contingency Plan Organizations within the State. In practice he may delegate the responsibility to an appointee of his choosing, subject to ratification by the senior State legislative body, or to the chief executive of cities and counties in his State. However, he may temporarily suspend this delegated authority and himself exercise line command over the Organization if, in his judgment, such action is warranted by the state of emergency..

6.1.1.2 Chief Operations Authority (COA)

The Chief Operations Authority (COA) is the appointee to whom the Governor may delegate the authority, including command of specified law enforcement units, for planning and directing the coordinated operations of all Contingency Plan participants, public and private.

6.1.1.3 COA Alternates

To ensure that the functions of Chief Operations Authority are always available, offices of First Alternate and Second Alternate may also be filled by Governor's appointment. In the event that the COA is unable to reach the Emergency Operations Center promptly after an accidental episode occurs, command should be taken over by the First Alternate or the Second Alternate, in that order, until the COA arrives at headquarters. The names and telephone numbers of the COA and designated First and Second Alternates should be included on any notices issued by the Organization.

6.1.2 Administration

It is recommended that administrative officers include at least a Chairman and an Executive Secretary. The office of Chairman might be rotated every two years among a list submitted by participating members. The Executive Secretary should be elected for a minimum of five years, preferably longer, to provide continuing services for the organization.

Additional administrative officers may be elected if so warranted by the size of workload of the Organization.

The following are illustrative sections that could be used as a model to define the duties and responsibility of Organization officers. Calendar dates and terms of office shown herein are optional.

6.1.2.1 Chairman

The Chairman will serve as spokesman for the Organization, sign all external correspondence, call meetings, and arrange practice drills. The Chairman will be elected by majority vote of all signatory Members, each member organization being entitled to one (1) vote. If no candidate has a majority, a run-off election will be held between the candidates having the highest and second highest number of votes. The Chairman's term of office shall begin on July 1,* and continue for a period of three (3) years. The incumbent Chairman may not succeed himself, except under conditions of Section 6.1.2.2.

6.1.2.2 Vice-Chairman

The Vice-Chairman will assist the Chairman in the performance of his duties and serve as Chairman during his absence. His term of office and manner of election shall be coincident with those of the Chairman. If a Chairmanship vacancy occurs during a term, the Vice-Chairman will automatically assume that office. A Vice-Chairmanship vacancy will be filled by the Advisory Board, by majority vote of Board Members present. A Vice-Chairman who has succeeded to the Chairmanship and will have served at least two full years by July 1* of an election year may not be a candidate for the next full term as Chairman.

6.1.2.3 Executive Secretary

The Executive Secretary will carry on the routine business of the Organization, which includes all internal correspondence, and responsibility for keeping manpower and material lists current, procuring maps and supplies for the EOC, obtaining Civil Defense identification cards for Contingency Response Team members, and issuing quarterly reports on activities and events that have involved the Organization. The Executive Secretary is also responsible for providing quarterly financial statements. He is authorized to engage part-time secretarial and auditor services to assist him in these efforts.

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*Dates are optional.

The Executive Secretary shall be elected in the same manner as the Chairman and Vice-Chairman, except that the term of office for the Executive Secretary shall be five (5) years. The incumbent may run for reelection at the end of his term, and if elected, serve no more than the second term. If the office is vacated prior to term expiration, the appointee to the unexpired term of two years or less is eligible to serve two additional full terms, a total of twelve (12) years.

6.1.3 Candidates for Office

On January 15* of each election year, the Chairman will appoint a nominating committee consisting of one person from each of three (3) Member units. This committee will recommend three other representatives as candidates for each of the offices to be vacated, and will receive other nominations that have at least five (5) valid signatures, that is, signatures of representatives from Member units. All candidates should be contacted by the nominating committee for their consent to permit their names to be listed on the ballots.

The nominating committee will have ballots complete and in the mail to each Member unit by April 15* of the election year. The Members will complete their respective ballots and return them to the designated address of the nominating committee by May 15,* one month later.

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* Dates are optional.

Newly elected officers will automatically assume their responsibilities on July 1[*] following their election without installation ceremony. Official announcement of the newly elected officials will be made by letter from the outgoing Chairman to all Members of the Organization.

6.2 ADVISORY BOARD

An Advisory Board is recommended in order that a mechanism be provided for independent critical review of Contingency Plan Organization effectiveness. Additional responsibilities should include the following:

(1) Establishing and maintaining liaison with Federal, State, local, and regional public and private organizations devoted to accidental episodes.

(2) Reviewing the Contingency Plan at least once yearly to consider effects of newly enacted legislation, to consider suggested amendments and additions, and to circulate these suggestions to Contingency Plan members for comment and recommendation.

(3) Reviewing contingency plans of other organizations for ideas and procedures that could be beneficial.

(4) Maintaining a permanent file of emergency action plans of all industries in the cognizant area where hazardous materials are manufactured, used, stored, or transported.

(5) Recommending necessary research, development, and testing by appropriate organizations of materials, equipment, and methods for the prevention and control of accidental episodes.

(6) Evaluating simulation drills and making recommendations based on these results.

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[*] Dates are optional.

6.2.1 Board Membership

The Advisory Board should consist of at least five members, such as the following:

- One or two members appointed by the Chief Executive of each participating County government.
- One or two members appointed by the mayor or city manager of each participating municipal government.
- Ex-officio, Chairman and Executive Secretary of the Contingency Plan Organization, on a non-voting basis.

The Board chairmanship could be filled by the voting members either through election or rotation for a specified period of time.

6.2.2 Meetings

The Board should meet periodically on a prescribed schedule (e.g., quarterly) and at any other time at the request of the Chairman or of any two Board members. In the event the Chairman of the Contingency Plan Organization vacates the office before his term expires, the Vice-Chairman shall thereupon become Chairman of the Organization and ex-officio member of the Advisory Board. Within thirty (30) days thereafter, the Board shall hold a special meeting to fill the vacated Vice-Chairmanship. See Section 6.1.2.2. In the event the office of Executive Secretary is vacated before term expiration date, the Board should hold a meeting within thirty (30) days to elect a successor.

6.2.3 Staff

The Board should be authorized to engage a secretary and an administrative assistant to assist them in performance of their duties. In addition, the Board should be authorized to engage legal consulting service as required.

6.2.4 Budget

The Board shall also have the responsibility of constructing (1) a budget, and (2) a schedule of assessments for participating Members. A fiscal committee will prepare these items for presentation to the Board at its last regular meeting before the fiscal year ends. Upon endorsement by the full Board, the items will be submitted to the Organization Members for a vote. In the event either or both items are rejected by majority vote of ballots received, a plenary meeting of Board and Organization Members will be held to reconcile differences before the fiscal New Year. The budget shall include annual compensation for the Executive Secretary and his staff, for members of the Advisory Board staff and consultant services, and daily compensation including reimbursement of expenses for the Chief Operations Authority and the On-Scene Commander, if these individuals are not already receiving compensation from Organization Members.

6.3 ORGANIZATION MEMBERSHIP

Two kinds of affiliation with the Organization are recommended, namely, Membership and Association. All affiliating agencies, public and private, that meet specified conditions would be eligible for Membership; those that do not would remain Associates. These conditions are:

(1) Each Member agrees to maintain personnel and equipment of sufficient capability to control fires or releases of hazardous chemicals of the type and magnitude that are likely to occur most often in their facilities.

(2) Each Member agrees to provide an Emergency Plan for activating these personnel and equipment within their facilities. Included in this plan, each Member also agrees to provide instructions for properly requesting and receiving aid from the Contingency Plan Organization in the event a fire or emergency develops, or has the potential of developing beyond the control of the in-plant personnel and or material.

(3) Each Member agrees to provide current lists of manpower and materials which, under most circumstances, could be furnished to the scene of an accidental episode as the Chief Operations Authority requests. In this connection, each Member also agrees to furnish lists of their responsible officials, including home addresses and telephone numbers, and an order of priority for their notification.

(4) Each Member agrees to appoint a representative and one alternate representative, at least one of whom will attend all meetings of the Organization insofar as practicable.

(5) Each Member agrees to participate in all practice drills of the Organization to the minimum extent of having one of their representatives present as an observer.

(6) Each Member agrees to replace material and/or equipment used or damaged in the control of a fire or emergency situation within its own facilities, replacement being in kind or in cash at current prices, provided the material and/or equipment was furnished by another Member or Associate or by members of a cooperating Contingency Plan Organization in response to a properly placed request.

The chief characteristics of Members are that:

- They are located in the general community
- They have capabilities and/or experienced personnel to participate in action responsive to an accidental episode or other disaster.
- They are professionally concerned with public safety, health, and welfare.

The chief characteristics of Associates are that:

- They are usually not located in the general community, although they may be.
- Their charter or tradition does not provide for signatory involvement in local agreements.
- They nevertheless have professional concern in supporting local agreements to promote public safety, health, and welfare, and can provide certain types of emergency services through their special capabilities.

To illustrate, the local Fire Department and Civil Defense Office would be Members; the Manufacturing Chemists Association of Washington, D. C. would be an Associate; the local offices of National Weather Service and the U. S. Coast Guard may elect either status. The local

Air Pollution Control agency should become a Member if it is not already so. Table G-1 in Appendix G shows a typical list of agencies that may be expected to participate as Members (M) or Associates (A) of a local Contingency Plan Organization. During any particular event, only specified ones will provide on-the-scene service, while others may be alerted to be on tap if needed. (See Section G.2.) The degree of participation will depend upon the nature and severity of the event. Special services are noted as appropriate.

For agencies that provide nationwide services through a central telephone number, that number is provided. For local and regional agencies, or local branches of a national agency, space is provided for entry of the local telephone contact. This form could be incorporated into the Master Directory recommended in 5.6.10. A cross-indexed list of equipment and services with their respective sources is presented in Appendix G, Section G.2.

6.4 CHECK LIST FOR ACCIDENTAL-EPISODE READINESS

Check, as Applicable

6.4.1 Contingency Plan

Basic plan prepared and current ____

Appendices and annexes current ____

Provides for mutual aid by signatories to the Plan ____

Reviewed by the local Disaster and Civil Defense Commission, or equivalent ____

Approved by State ____

Copies furnished to Commission and the State ____

6.4.2 Contingency Plan Organization

Plan effective use of existing staff ____

Provide clear lines of direction and coordination ____

Designate key personnel assignments ____

Designate sufficient alternates to key personnel ____

Assign emergency duties ____

Insure that personnel understand disaster duties ____

Properly register volunteer disaster service workers ____

Fill vacant key positions ____

7. CONTINGENCY PLAN IMPLEMENTATION: STANDARD OPERATING PROCEDURES

The second requirement for Contingency Plan Implementation is a set of Standard Operating Procedures (SOP). This is the document that specifies what steps are to be taken when an accidental episode occurs. It states who is to receive the initial report of the event, how it is verified, what key personnel are notified, where they report, what their duties and responsibilities are, how the public is notified and if necessary evacuated, what measures are taken to neutralize and remove the hazard, and when emergency measures are terminated.

This chapter presents guidelines for an SOP that is based upon four operational stages, the Readiness Stage and three Alert Stages. To each stage there is a corresponding sequence of activity, personnel assignments, and Operational Mode for the Emergency Operations Center (EOC). The Operational Modes are designated as follows:

ALERT STAGE	OPERATIONAL MODE
First	Partial Activation
Second	Full Activation
Third	Emergency Activation

7.1 READINESS STAGE

The Readiness Stage covers three types of activity.

- Routine Surveillance
- Practice Drills
- Immediate Response

7.1.1 Routine Surveillance

7.1.1.1 Officials on Duty

During the day-to-day activity of those responsible for public safety, mainly the police and fire departments, patrols are routinely on the lookout for all types of emergency events. Weeks, months, perhaps years may pass without involvement of a given locality in a hazardous chemical event. Nevertheless, few localities are immune. Should an unexpected disaster of this type occur, damage and casualties can be kept to a minimum through a preplanned response effort.

During routine surveillance, physical manning of the EOC is normally not required. However, responsibilities for receiving the initial report of an accidental episode and initiating prompt action thereto should be assigned to the Operations Duty Officer. He will be one of the senior police officers at headquarters during daytime working hours. At night, these duties might be delegated to the headquarters desk sergeant.

The Operations Duty Officer may be assisted by one or more Warning Controllers. These are lower rank police or fire department personnel whose normal duties include receiving and screening incoming telephone and radio calls.

7.1.1.2 Public Awareness

The public at large should be made aware of procedures to follow if one discovers an accidental release of potentially hazardous material. Posters should be prominently displayed and warnings should be periodically disseminated over popular news media. Figure 7-1 illustrates a typical notice.

7.1.2 Practice Drills

The manner in which Contingency Plan Organization Teams respond to simulated alerts is a measure of their effectiveness during an actual event. Practice drills should therefore be held periodically, at least once every six months, preferably more often. Drills scheduled in advance may serve as the occasion for instruction and teamwork development. Once the teams have performed smoothly on several scheduled drills, they should be tested on unscheduled drills in which different hazardous commodities, carriers, episode sites, and release mechanisms are simulated. Designated Board members

NOTIFICATION

OCCURRENCE OF AN ACCIDENTAL EPISODE

IF YOU SEE QUANTITIES OF POTENTIALLY HAZARDOUS VAPORS ESCAPING FROM A BUILDING, TRUCK, TANK CAR, OR VESSEL:

1. **WARN** OTHER PEOPLE IN THE AREA IMMEDIATELY.
2. **TELEPHONE** "OPERATOR", ASK FOR "EMERGENCY" OR CALL EMERGENCY NUMBER DIRECT.
3. **INTERCEPT** RESPONDING UNITS AT A SAFE DISTANCE FROM THE SCENE.
4. **HELP** THEM LOCATE THE SPILLAGE. THEN LEAVE THE AREA OR FOLLOW THEIR INSTRUCTIONS.

Figure 7-1. Sample of Notification

should observe and evaluate the practice drills, and report their findings and recommendations to the Contingency Plan Organization Chairman.

7.1.3 Readiness Periodic Check List

Insure that:

SOP's for each service are prepared and current ____
SOP or manual for staff and EOC operations are prepared and current ____
Key personnel are trained in emergency functions ____
Emergency communications are adequate ____
Alert notification lists are current ____
Sources of aid and assistance are known ____

7.1.4 Immediate Response

Once an accidental episode occurs, quick action on everyone's part may help to save lives. Responsive action must not await the formal declaration of an Alert Stage by the Chief Operations Authority. The few things that are done in the earliest moments oafter hazardous material escapes into the air could be critical to the source of ensuing events.

7.1.4.1 Initial Report

An accidental episode may be discovered by a plant employee, a truck driver, a Highway Patrol car, or other passerby. That person should immediately contact police or fire department headquarters by calling the operator or a well-publicized emergency telephone number. Highway Patrol contact would normally be over police radio. In either case, the report would be received by a Warning Controller, who immediately notifies the Operations Duty Officer.

The individual reporting the event should be asked for the following information:

1. Location of the release or spillage of hazardous material
2. An estimate of the quantity being released, and the speed and direction in which it is heading
3. Inhabited structures in the path of the moving cloud
4. Identification and description of the source: stationary or mobile, type of plant or vehicle, numbers involved, persons on the scene, etc.
5. Identifying labels if any, such as:
    a. Warning placards
    b. Name of the chemical
    c. Other

7.1.4.2 Response Procedure

(1) The Warning Controller or Operations Duty Officer receiving the initial report from an individual other than a Highway Patrolman or other Contingency Team member will request him to alert persons who are in the apparent path of the cloud, unless his own personal safety could be jeopardized. Otherwise, he will be advised to leave the scene without delay.

(2) If the initial report has been sent from a Highway Patrol car, the Operations Duty Officer or Warning Controller will request it remain on the scene to provide emergency assistance and further information as needed. Otherwise, the Operations Duty Officer will dispatch a patrol car to the scene for verifying information, and one or more additional patrol cars for emergency assistance.

(3) In the meantime, the Warning Controller will notify the Chief Operations Authority and the On-Scene Commander.

(4) The Operations Duty Officer will seek to acquire as much information as possible on how to handle the escaping material. If the source is a vehicle in transit and essential information is not readily provided by eyewitnesses and local information sources, the Operations Duty Officer should call the toll-free CHEMTREC number:

(800) 424-9300; in the Washington, D.C. area, 483-7616

From fragments of information provided them, the specialists who man the telephone on a 24-hour per day basis may identify and notify the shipper or carrier and determine the exact nature of the cargo and how a spillage is to be handled. If the material is identified at the scene, CHEMTREC will advise directly on its handling.

(5) When the initial report is confirmed by police officers on the scene, the Operations Duty Officer prepares the EOC for activation. The Disaster Services Coordinator and the news media are notified.

(6) The Operations Duty Officer serves as Acting Chief Operations Authority until the designated Chief Operations Authority arrives. At the episode site, the first police unit reaching the scene will take charge of activity until relieved by a higher ranking officer or by the designated On-Scene Commander. Each designated official should reach his respective post within fifteen minutes after notification.

(7) The Chief Operations Authority will assess the situation, determine which Alert Stage, if any, is called for, and make the appropriate declaration.

The overall pre-Alert Stage activity is shown schematically in Figure 7-2.

7.1.5 Readiness Task Assignment Details

7.1.5.1 Duty Hours: Three Eight-hour Shifts, as Follows:

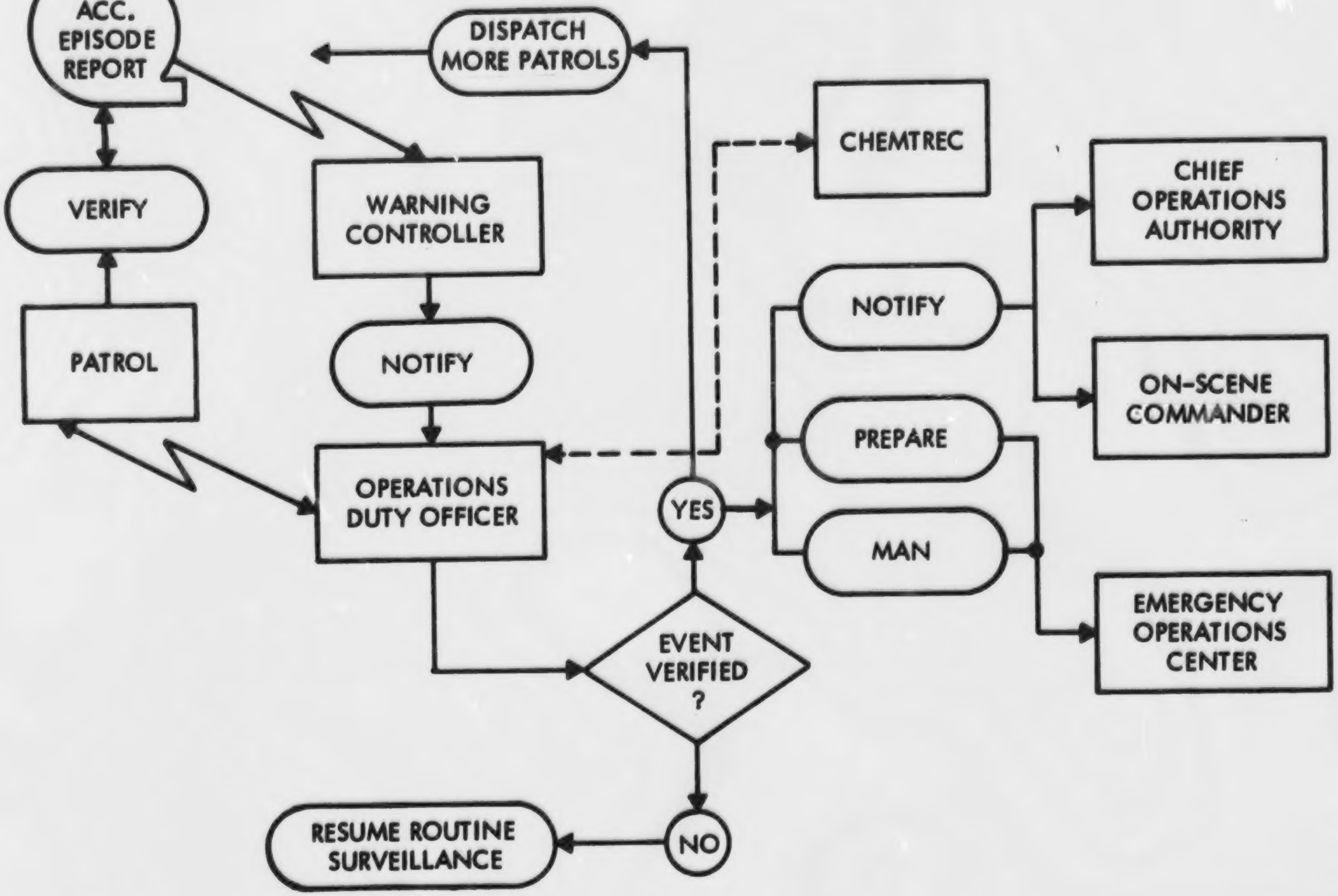
Shift A: 0000 to 0800 hours
Shift B: 0800 to 1600 hours
Shift C: 1600 to 0000 hours

7.1.5.2 Operations Duty Officer

This assignment should be rotated on a shift basis among Headquarters police officers holding the rank of sergeant or above.

Duties include:

- Inspecting the EOC (morning shift only) to ensure availability and operational condition of all equipment.
- Securing the EOC when it is not in use.
- Assigning Warning Controllers.
- Receiving the first reports that an accidental episode may have occurred.
- Notifying mobile units nearest to the reported event to validate the reports on-scene.



ACC. EPISODE REPORT
VERIFY
PATROL
DISPATCH MORE PATROLS
WARNING CONTROLLER
NOTIFY
OPERATIONS DUTY OFFICER
CHEMTREC
YES
EVENT VERIFIED ?
NO
RESUME ROUTINE SURVEILLANCE
NOTIFY
PREPARE
MAN
CHIEF OPERATIONS AUTHORITY
ON-SCENE COMMANDER
EMERGENCY OPERATIONS CENTER

Figure 7-2. **Readiness Procedures on Initial Notification of an Accidental Episode**

- Obtaining as much initial data as possible about the event and hazardous chemical from eyewitnessed, local information sources and CHEMTREC.
- Notifying the Chief Operations Authority and the On-Scene Commander.
- Communicating with as many units as appear to be needed to move to the scene without delay to render assistance.
- Disseminating the following WARNING:
  DO NOT ENTER OR MOVE ABOUT INSIDE OF A POTENTIALLY HAZARDOUS CLOUD WITHOUT PROPER PROTECTION GEAR IN PLACE (gas masks, protective clothing). FORBID SMOKING, SPARKS, AND OPEN FLAMES.
- Opening, preparing, and manning the EOC.
- Contacting news media for aid in disseminating warnings.

7.1.5.3 Warning Controllers

This assignment should be rotated on a shift basis among personnel on duty at each Public Safety station, including Headquarters and local stations of the Police and Fire Departments, County Police, Highway Patrol, Volunteer Fire Departments, and guards at local airports.

Duties include:

- Maintaining radio contact with mobile patrols on routine police surveillance.
- Receiving first notice that an accidental episode may have occurred.
- Immediately notifying the Operations Duty Officer and providing assistance to him by obtaining information on:
  a. LOCATION and TIME of the occurrence.
  b. NATURE of the Source: STATIONARY (industrial plant, government installation, other) or MOBILE (railroad tank car, truck, barge, etc.; type of vehicle and container)
  c. NATURE of the SPILLED MATERIAL, if readily identifiable from labels or direct information from the handler (plant engineer, tank truck driver, etc.)

d. ESTIMATED AMOUNT and apparent MOVEMENT of the spilled material.
e. NEED for ADDITIONAL SUPPORT: police, fire, special units, ambulances, medical personnel.

Note: If the hazardous material can not be identified, the reported information should include, if available:

1. NAME of the plant or carrier (truck, railroad car, etc.)
2. PHYSICAL CHARACTERISTICS of the hazardous cloud: color, smell, physical effects on people.

- Advise mobile unit to take full charge of all activity until relieved by an official of higher rank or by the On-Scene Commander (OSC) of the Contingency Response Team.

Upon validation of episode occurrence, Warning Controller(s) at Police Headquarters will take assigned positions at the EOC.

7.2 FIRST STAGE ALERT: PARTIAL ACTIVATION

7.2.1 Sequence of Activity

On the basis of information received and verified during the Readiness Stage, the Chief Operations Authority may proclaim a First Stage ALERT and call for Partial Activation of the EOC if the following conditions apply:

1. The amount of released material is not large enough to pose a threat to persons outside the property limits or right-of-way where the event has occurred.
2. Responsive efforts by persons on the scene, whether public safety units, tank truck, railroad, or barge personnel, or the cognizant Mutual Aid Association, are expected to eliminate the hazard within a reasonable period of time.

Figure 7-3 is a flow chart of the activity sequence. At the First Stage ALERT Declaration, represented by Ⓐ, the EOC is in operation and the On-Scene Commander is at or near the episode site. The Chief Operations Authority then activates the Disaster Services Coordinator and notifies the Stationary or Mobile Source Contingency Response Team to be on stand-by.

The On-Scene Commander takes charge of activities at the site, relieving the Acting On-Scene Commander of this responsibility. If the spill was found to be on one of the navigable waterways, the On-Scene Commander as prearranged would be the Commander, U.S. Coast Guard, who assumes direction of all activities on water.

In either case, since the spill is minor, persons connected with the installation or vehicle usually require little or no outside assistance to eliminate the hazard. If the on-scene resources are adequate, the Response Team members will stand-by, render assistance upon request, then notify the Chief Operations Authority that normal conditions have been

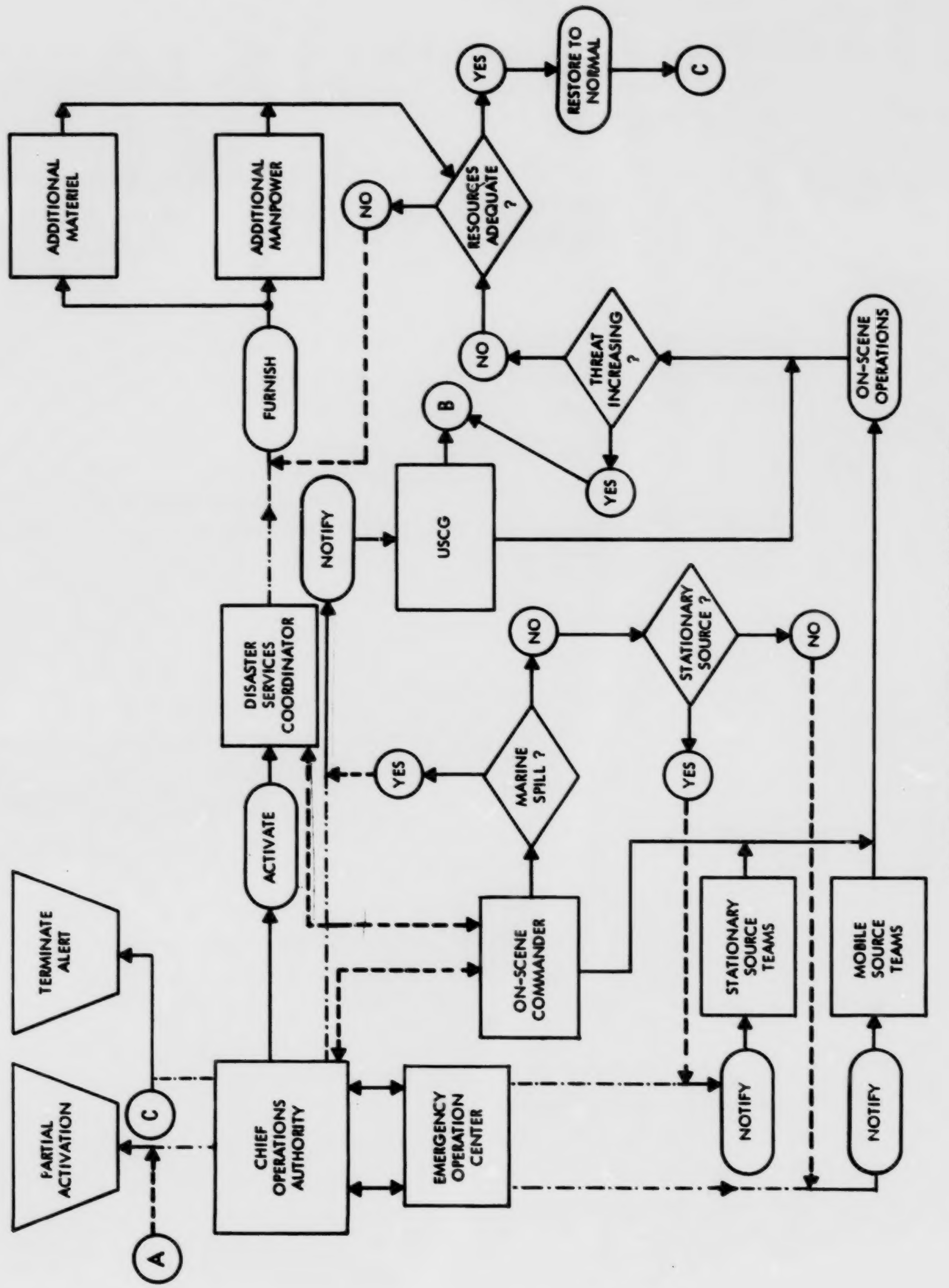

PARTIAL ACTIVATION
TERMINATE ALERT
A
C
CHIEF OPERATIONS AUTHORITY
EMERGENCY OPERATION CENTER
ACTIVATE
DISASTER SERVICES COORDINATOR
FURNISH
ADDITIONAL MATERIEL
ADDITIONAL MANPOWER
NO
RESOURCES ADEQUATE ?
YES
RESTORE TO NORMAL
C
NOTIFY
USCG
B
YES
THREAT INCREASING ?
NO
ON-SCENE OPERATIONS
ON-SCENE COMMANDER
YES
MARINE SPILL ?
NO
STATIONARY SOURCE ?
YES
NO
STATIONARY SOURCE TEAMS
MOBILE SOURCE TEAMS
NOTIFY
NOTIFY

Figure 7-3. Sequence of Activity during First Stage ALERT: Partial Activation

restored. When satisfied that this is so, indicated by Ⓒ , the Chief Operations Authority will announce ALERT TERMINATION.

However, the On-Scene Commander may decide that the "in-house" response is inadequate. Or, he may be apprised that conditions are changing and could develop an increasing threat to populated areas. The Chief Operations Authority may then decide to proclaim a Second Stage ALERT with the EOC in Full Activation, represented in Figure 7-3 by Ⓑ .

7.2.2 Task Assignment Details

(1) Operations Duty Officer: assignment described in 5.2.

Duties on ALERT status include:

- Ascertaining that the EOC premises are open only to authorized Contingency Response Team members
- Furnishing additional supplies that might be required at the EOC
- Coordinating internal communication among EOC members

(2) Chief Operations Authority: assignment described in 5.2.

(3) On-Scene Commander: assignment described in 5.2.

(4) Disaster Services Coordinator: assignment described in 5.2.

Additional duties on ALERT status at the EOC include:

- Maintaining an up-to-the-minute checklist on all manpower and equipment that are engaged in response to the episode
- Alerting or activating reserves of manpower and/or material as required
- Supervising all visual displays in the EOC, including maps and overlays used in locating units, equipment, populations, and the spread of hazardous material

- Maintaining periodic communication with the On-Scene commander
- Clearing major decisions with the Chief Operating Authority

(5) Commander, U. S. Coast Guard: the designated On-Scene Commander if the accidental episode occurs on or along any of the navigable waterways within the jurisdictional area. The captain of a Harbor Patrol boat that may reach the site first will serve as Acting OSC until the designated OSC arrives.

7.2.3 Emergency Operations Center Manning

In addition to the Chief Operations Authority, the Disaster Services Coordinator, the Operations Duty Officer, and the Warning Controllers, manning will include representatives from:

- Department of Highways
- Department of Public Works
- Fire Department of city or county where event occurred
- County Civil Defense Team
- News media

7.2.4 Contingency Operation Teams

During Partial Activation the Stationary or Mobile Source Teams, as the case may be, are not dispatched to the accidental episode site. The Stationary Teams Captain and the Mobile Team Captain are notified by telephone, and each in turn will alert his respective Team Leaders. All will await further radioed instructions.

7.3 SECOND STAGE ALERT: FULL ACTIVATION

When the report of an accidental episode has been verified, the Chief Operations Authority may declare a Second Stage ALERT if the following conditions apply:

1. A First Stage ALERT that has been in effect, with Partial Activation, appears to be inadequate for restoring normal conditions. The spillage is seen to be larger than originally estimated, and countermeasures by "in-house" personnel are not effective.
2. The airborne spread of hazardous material endangers populated areas, and some evacuations may be required.
3. The substance has not been identified, and the nature and degree of hazard can not be assessed for the present.

The Chief Operations Authority may then call for full activation of the Contingency Response Team. At his discretion, selected units whose services do not appear to be essential for the particular event may simply be notified, to await further radioed instructions.

7.3.1 Sequence of Activity

In Figure 7-4, the symbol Ⓑ is used to represent the proclamation a Second Stage ALERT, with Full Activation. The diagrammed events shown previously in Figure 7-3 apply to a Full Activation as well as a Partial Activation, except that either the Stationary or the Mobile Source Team, as appropriate, is activated instead of being only notified. Additional actions are taken as diagrammed in Figure 7-4. The complete schedule of activity is diagrammed in Figure 7-5.

In addition to the participants under Partial Activation, the Chief Operations Authority notifies the Governor and local government officials and orders the activation or the notification of the following, as he deems necessary:

- Red Cross, Salvation Army, Public Health, Public Works, and Highway teams: to provide emergency services as required.
- Air Pollution Control Agency: for on-scene monitoring and analysis of atmospheric contamination, and for hazard area estimates.

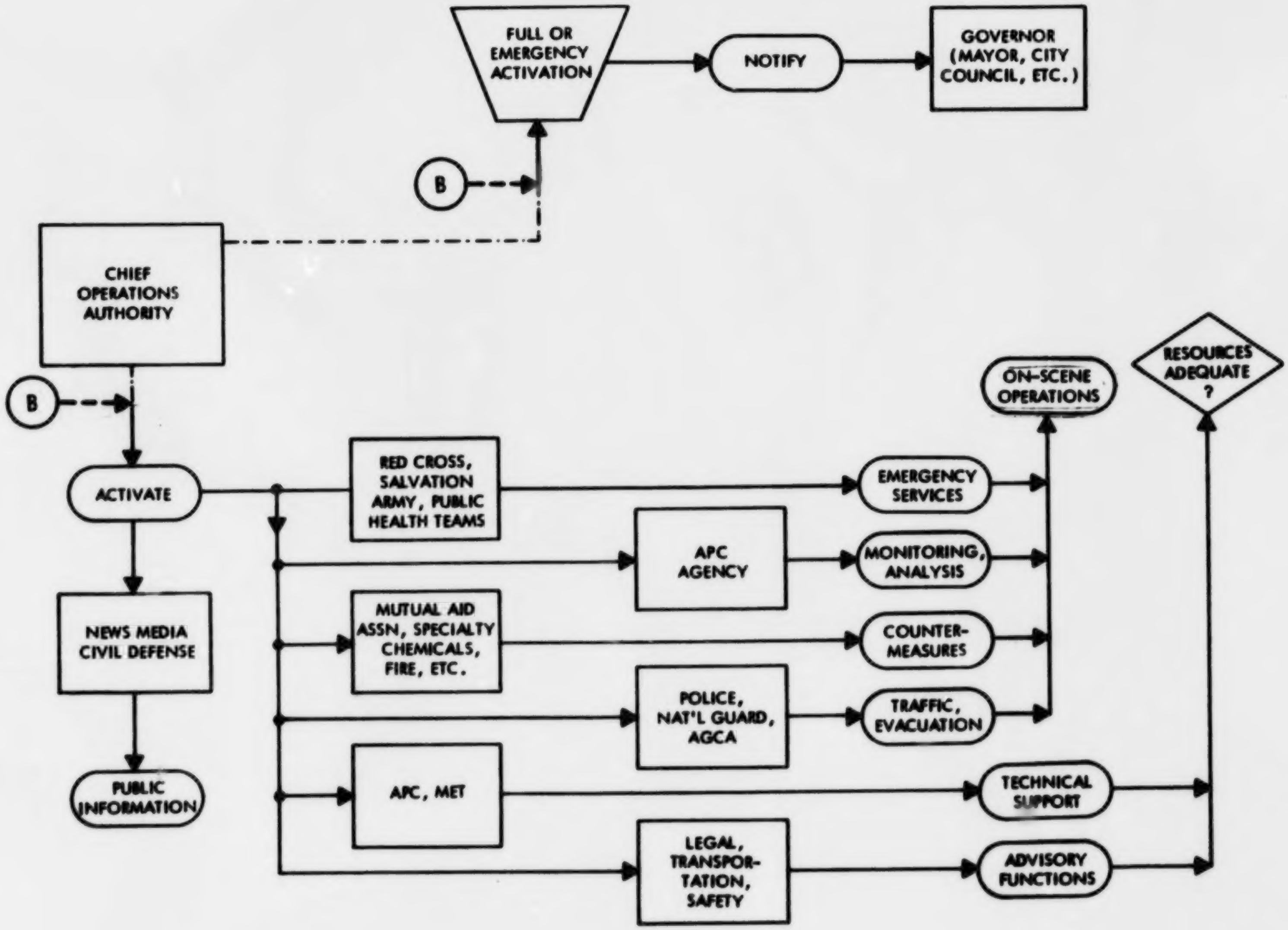

FULL OR EMERGENCY ACTIVATION
NOTIFY
GOVERNOR (MAYOR, CITY COUNCIL, ETC.)
B
CHIEF OPERATIONS AUTHORITY
B
ACTIVATE
NEWS MEDIA CIVIL DEFENSE
PUBLIC INFORMATION
RED CROSS, SALVATION ARMY, PUBLIC HEALTH TEAMS
APC AGENCY
MUTUAL AID ASSN, SPECIALTY CHEMICALS, FIRE, ETC.
POLICE, NAT'L GUARD, AGCA
APC, MET
LEGAL, TRANSPORTATION, SAFETY
EMERGENCY SERVICES
MONITORING, ANALYSIS
COUNTER-MEASURES
TRAFFIC, EVACUATION
TECHNICAL SUPPORT
ADVISORY FUNCTIONS
ON-SCENE OPERATIONS
RESOURCES ADEQUATE ?

Figure 7-4. Additional Sequence of Activity during Second and Third ALERT Stages: Full and Emergency Activation

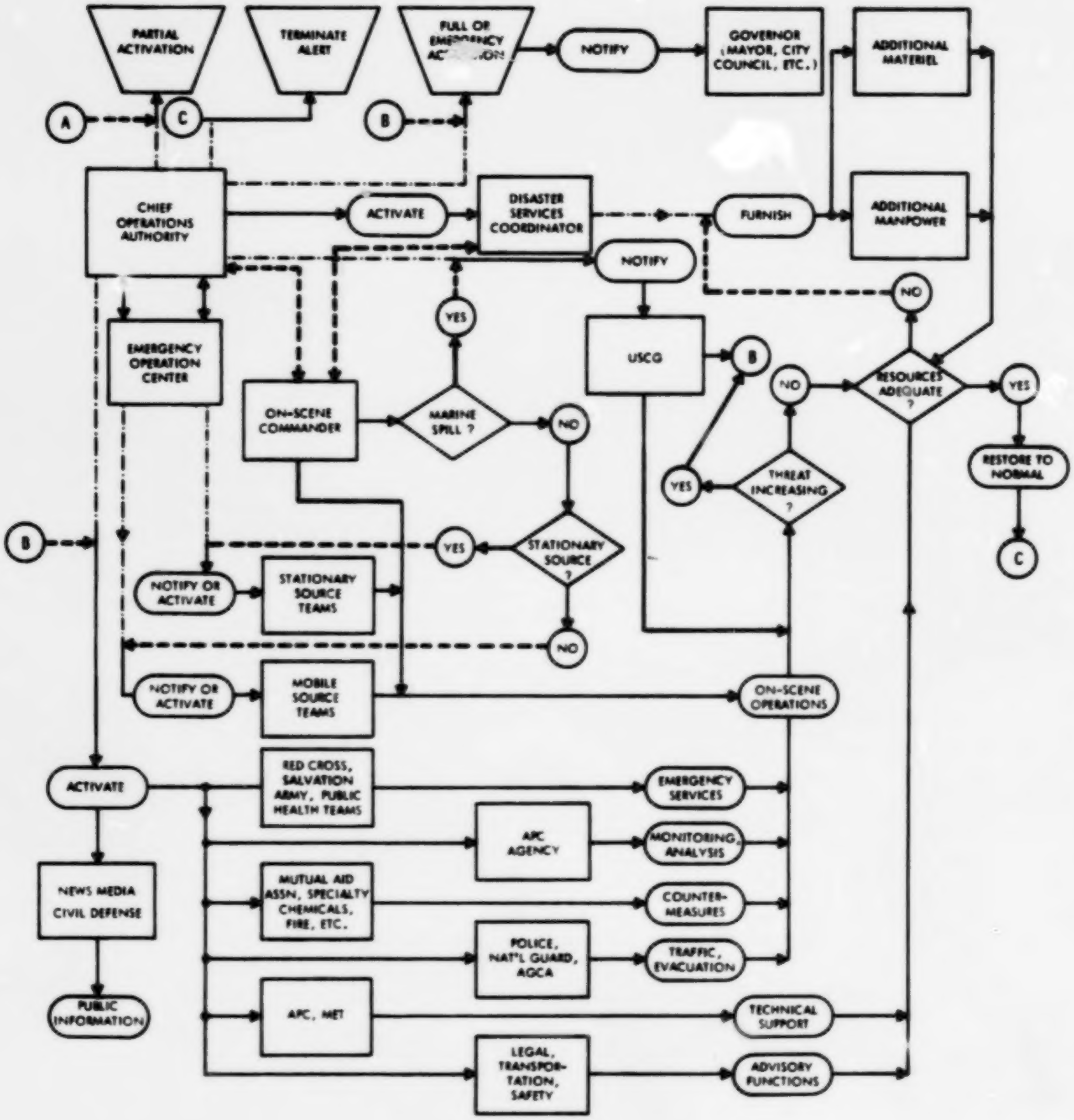

PARTIAL ACTIVATION
TERMINATE ALERT
FULL OR EMERGENCY ACTIVATION
NOTIFY
GOVERNOR (MAYOR, CITY COUNCIL, ETC.)
ADDITIONAL MATERIEL
A
C
B
CHIEF OPERATIONS AUTHORITY
ACTIVATE
DISASTER SERVICES COORDINATOR
FURNISH
ADDITIONAL MANPOWER
NOTIFY
NO
YES
USCG
B
EMERGENCY OPERATION CENTER
ON-SCENE COMMANDER
MARINE SPILL ?
NO
NO
RESOURCES ADEQUATE ?
YES
THREAT INCREASING ?
YES
RESTORE TO NORMAL
C
B
YES
STATIONARY SOURCE ?
NOTIFY OR ACTIVATE
STATIONARY SOURCE TEAMS
NO
NOTIFY OR ACTIVATE
MOBILE SOURCE TEAMS
ON-SCENE OPERATIONS
ACTIVATE
RED CROSS, SALVATION ARMY, PUBLIC HEALTH TEAMS
EMERGENCY SERVICES
APC AGENCY
MONITORING, ANALYSIS
NEWS MEDIA CIVIL DEFENSE
MUTUAL AID ASSN, SPECIALTY CHEMICALS, FIRE, ETC.
COUNTER-MEASURES
POLICE, NAT'L GUARD, AGCA
TRAFFIC, EVACUATION
PUBLIC INFORMATION
APC, MET
TECHNICAL SUPPORT
LEGAL, TRANSPOR-TATION, SAFETY
ADVISORY FUNCTIONS

Figure 7-5. Total ALERT Sequence of Activity

- Industrial Mutual Aid Associations, special Fire Department Units, for countermeasures (the set of actions taken to contain, neutralize, and eliminate the spillage of hazardous material); also, upon request of the On-Scene Commander, specialty teams for handling chlorine, pesticides, etc.
- Police, U. S. Army Engineers, Associated General Contractors of America: to evacuate endangered persons, clear obstacles to traffic, etc.
- Legal, Transportation, and Safety offices: for support as required.

The countermeasures to be employed in each particular event will depend upon the cause of the accident, the condition of the container and carrier, and the characteristics of the hazardous material. The use of countermeasures is assigned exclusively to experienced and trained personnel. These persons will know what protective gear to wear and counteractive measures to employ in each event.

7.3.2 Manning and Description of Duties

(1) Operations Duty Officer: assignment described in 5.2.

(2) Chief Operations Authority: assignment described in 5.2.

(3) On-Scene Commander: assignment described in 5.2

(4) Disaster Services Coordinator: assignment described in 7.2.2.

Additional duties under Full Activation include:

- Contacting the listed sources of additional or specialty manpower and/or equipment as requested by the On-Scene Commander and endorsed by the Chief Operations Authority. See below under Sequence of Activity.

(5) Commander, U. S. Coast Guard: assignment described in 7.2.2.

Additional duties under Full Activation include:

- Directing countermeasures and emergency services in combatting a marine spillage.

(6) Stationary Teams Captain

This post is assigned to an individual who has been jointly recommended or elected by the stationary source team members and endorsed by the On-Scene Commander, to whom he reports.

Duties include:

- Mustering Contingency Operations Team members that are especially trained and equipped to eliminate the hazard and to provide for the safety of persons in the affected area.
- Calling up only those units that in his judgment are sufficient to perform the job. (Too often, on-scene operations are hampered instead of facilitated by the presence of redundant personnel.)
- Directing countermeasures and if necessary personally participating therein.
- Keeping the On-Scene Commander fully informed of the progress of his teams' efforts.
- Providing the On-Scene Commander with information required for decisions on additional needs such as identification, monitoring, and analysis of spillage material, or the emergency call-up of a chemical specialty team (chlorine, pesticide, etc.).

(7) Mobile Teams Captain

This post is assigned to an individual who has been jointly recommended or elected by the transportation members of the Plan and endorsed by the On-Scene Commander, to whom he reports. He is familiar with regulations, practices, and problems of all carrier modes. Duties are the same as for Stationary Teams Captain (see above).

Additional duties include:

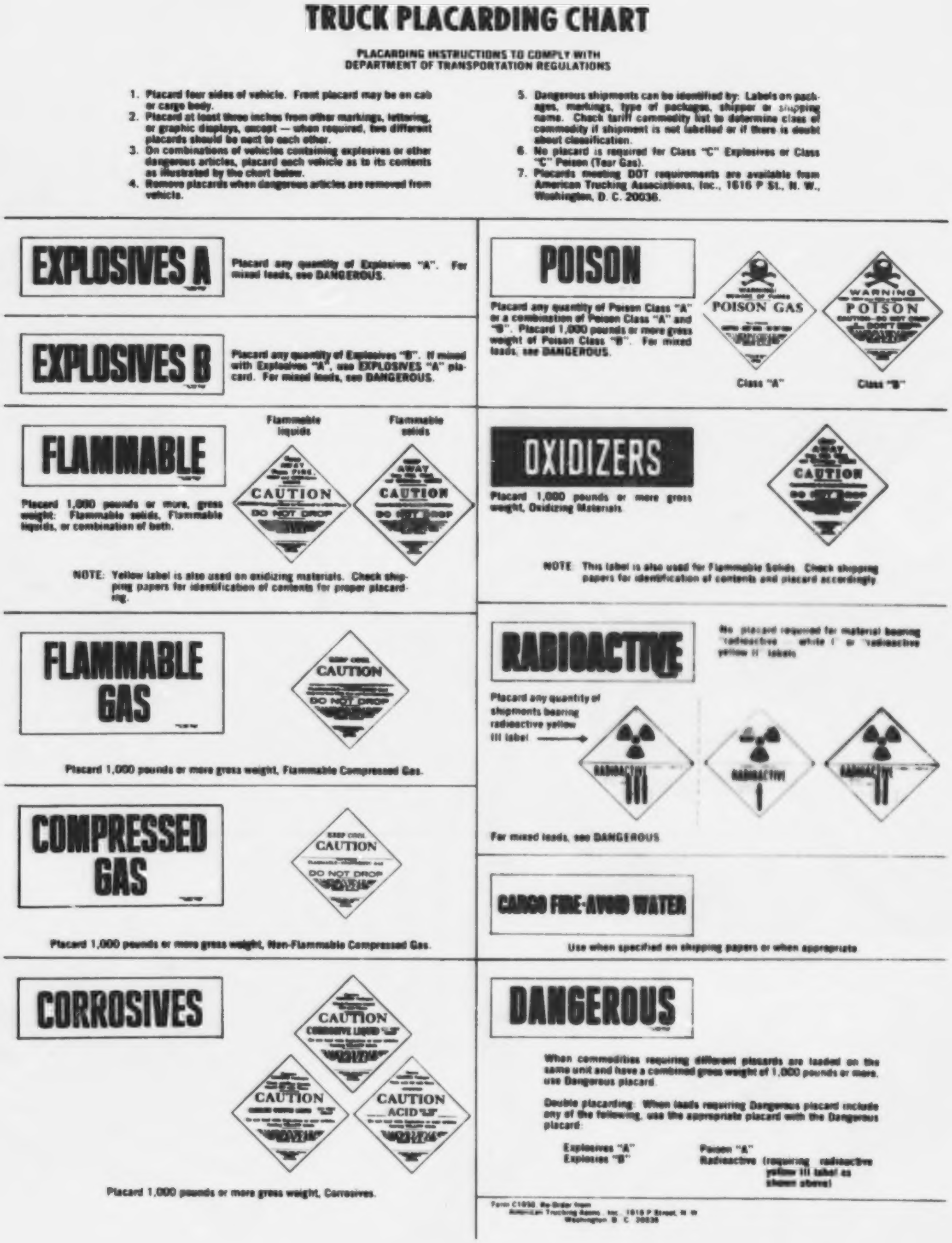
- Reporting all possible information to the On-Scene Commander that can help determine required particulars concerning the cargo, including the name and telephone number of the shipper.

- Stationing police units to maintain security about the site (to prevent looting, unnecessary casualties, etc.)
- Requesting special assistance from wrecking crews, welders, etc., that in his judgment are required to clear roads or tracks, contain the spillage, free couplings, etc.

7.3.3 Emergency Information Sources

Situations where released material is unidentified seldom occur at fixed sites, since persons at each industrial plant usually know what hazardous substances are handled there. However, in many accidental episode cases from mobile sources, the escaping material is not immediately identified, since the tank truck driver, barge captain or railroad engineer may have fled the scene or may himself be overcome by the vapors. The following actions should be taken to help identify the material.

- If the vehicle can be approached with safety from upwind, look for identifying labels of all kinds that might give the name of the carrier or shipper, vehicle registration number, and warnings on cargo characteristics and handling. Look for placards that carry cargo identification and warning. Exhibits 7-1 and 7-2 show the kinds of placards displayed on trucks in accordance with Department of Transportation regulations. A more complete set of placards is included in Appendix E.
- If the cab is accessible, look for a Chem-Card (Exhibit 7-3 and Appendix E) that accompanies most vehicles that carry hazardous material.
- If no cargo identification can be found, radio as much information as is available to the On-Scene Commander. He will relay the information to the EOC. The EOC, in turn, may telephone the Manufacturing Chemists' Association CHEMTREC


Flammable liquids
Flammable solids
CAUTION
DO NOT DROP
POISON GAS
WARNING
POISON
RADIOACTIVE
III
I
II
CAUTION
ACID

TRUCK PLACARDING CHART

PLACARDING INSTRUCTIONS TO COMPLY WITH
DEPARTMENT OF TRANSPORTATION REGULATIONS

1. Placard four sides of vehicle. Front placard may be on cab or cargo body.
2. Placard at least three inches from other markings, lettering, or graphic displays, except — when required, two different placards should be next to each other.
3. On combinations of vehicles containing explosives or other dangerous articles, placard each vehicle as to its contents as illustrated by the chart below.
4. Remove placards when dangerous articles are removed from vehicle.
5. Dangerous shipments can be identified by: Labels on packages, markings, type of packages, shipper or shipping name. Check tariff commodity list to determine class of commodity if shipment is not labelled or if there is doubt about classification.
6. No placard is required for Class "C" Explosives or Class "C" Poison (Tear Gas).
7. Placards meeting DOT requirements are available from American Trucking Associations, Inc., 1616 P St., N. W., Washington, D. C. 20036.

EXPLOSIVES A

Placard any quantity of Explosives "A". For mixed loads, see DANGEROUS.

EXPLOSIVES B

Placard any quantity of Explosives "B". If mixed with Explosives "A", see EXPLOSIVES "A" placard. For mixed loads, see DANGEROUS.

FLAMMABLE

Placard 1,000 pounds or more, gross weight: Flammable solids, Flammable liquids, or combination of both.

NOTE: Yellow label is also used on oxidizing materials. Check shipping papers for identification of contents for proper placarding.

FLAMMABLE GAS

Placard 1,000 pounds or more gross weight, Flammable Compressed Gas.

COMPRESSED GAS

Placard 1,000 pounds or more gross weight, Non-Flammable Compressed Gas.

CORROSIVES

Placard 1,000 pounds or more gross weight, Corrosives.

POISON

Placard any quantity of Poison Class "A" or a combination of Poison Class "A" and "B". Placard 1,000 pounds or more gross weight of Poison Class "B". For mixed loads, see DANGEROUS.

Class "A" Class "B"

OXIDIZERS

Placard 1,000 pounds or more gross weight, Oxidizing Materials.

NOTE: This label is also used for Flammable Solids. Check shipping papers for identification of contents and placard accordingly.

RADIOACTIVE

No placard required for material bearing "radioactive — white I" or "radioactive yellow II" labels.

Placard any quantity of shipments bearing radioactive yellow III label →

For mixed loads, see DANGEROUS

CARGO FIRE-AVOID WATER

Use when specified on shipping papers or when appropriate

DANGEROUS

When commodities requiring different placards are loaded on the same unit and have a combined gross weight of 1,000 pounds or more, use Dangerous placard.

Double placarding: When loads requiring Dangerous placard include any of the following, use the appropriate placard with the Dangerous placard:

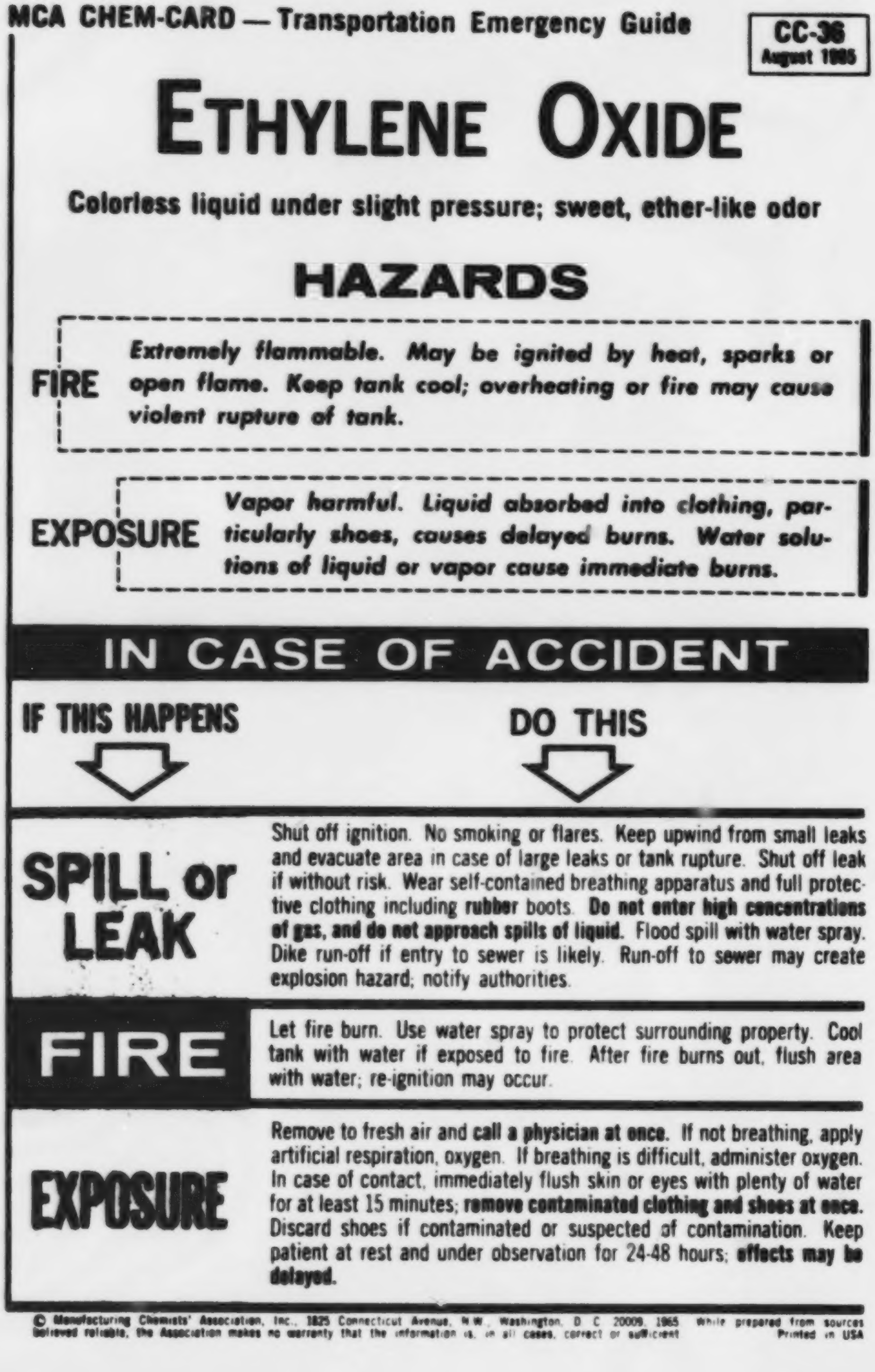
Explosives "A"	Poison "A"
Explosies "B"	Radioactive (requiring radioactive yellow III label as shown above)

Form C1050, Re-Order from
American Trucking Assns., Inc., 1616 P Street, N.W.
Washington, D. C. 20036

Exhibit 7-1. Truck Placarding Chart

HAZARD	SIGNS (TRUCKS)	PLACARD & LABEL
EXPLOSIVES A	WHITE BACKGROUND RED LETTERS	RED LABEL BLACK LETTERS
EXPLOSIVES B	WHITE BACKGROUND RED LETTERS	RED LABEL BLACK LETTERS
POISON (A & B)	WHITE BACKGROUND BLUE LETTERS	WHITE LABEL RED LETTERS
FLAMMABLE	WHITE BACKGROUND RED LETTERS	RED LABEL BLACK LETTERS
OXIDIZERS	BLACK BACKGROUND YELLOW LETTERS	YELLOW LABEL BLACK LETTERS
COMPRESSED GAS	WHITE BACKGROUND GREEN LETTERS	GREEN LABEL BLACK LETTERS
CORROSIVES	WHITE BACKGROUND BLUE LETTERS	WHITE LABEL BLACK LETTERS
FLAMMABLE GAS	WHITE BACKGROUND RED LETTERS	RED LABEL BLACK LETTERS
RADIOACTIVE III	YELLOW BACKGROUND BLACK LETTERS	YELLOW & WHITE LABEL BLACK LETTERS
DANGEROUS	WHITE BACKGROUND RED LETTERS	WHITE LABEL BLACK LETTERS

Exhibit 7-2. Department of Transportation Classification and Marking of Hazardous Materials



MCA CHEM-CARD — Transportation Emergency Guide

CC-36
August 1965

ETHYLENE OXIDE

Colorless liquid under slight pressure; sweet, ether-like odor

HAZARDS

FIRE *Extremely flammable. May be ignited by heat, sparks or open flame. Keep tank cool; overheating or fire may cause violent rupture of tank.*

EXPOSURE *Vapor harmful. Liquid absorbed into clothing, particularly shoes, causes delayed burns. Water solutions of liquid or vapor cause immediate burns.*

IN CASE OF ACCIDENT

IF THIS HAPPENS	DO THIS
SPILL or LEAK	Shut off ignition. No smoking or flares. Keep upwind from small leaks and evacuate area in case of large leaks or tank rupture. Shut off leak if without risk. Wear self-contained breathing apparatus and full protective clothing including **rubber** boots. **Do not enter high concentrations of gas, and do not approach spills of liquid.** Flood spill with water spray. Dike run-off if entry to sewer is likely. Run-off to sewer may create explosion hazard; notify authorities.
FIRE	Let fire burn. Use water spray to protect surrounding property. Cool tank with water if exposed to fire. After fire burns out, flush area with water; re-ignition may occur.
EXPOSURE	Remove to fresh air and **call a physician at once.** If not breathing, apply artificial respiration, oxygen. If breathing is difficult, administer oxygen. In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes; **remove contaminated clothing and shoes at once.** Discard shoes if contaminated or suspected of contamination. Keep patient at rest and under observation for 24-48 hours; **effects may be delayed.**

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Exhibit 7-3. Sample MCA CHEM-CARD

number, (800) 424-9300, which provides 24-hour a day telephone assistance on hazardous materials in transport.

- If no information of the type described above is available, the local Air Pollution Control Agency may be able to assist in field monitoring and identification. A few APC agencies may have a mobile laboratory with field personnel who are trained in air sampling and analysis.
- Once the substance is identified, further information may be available through the APC Agency or the CHEMTREC number regarding characteristics of the hazardous material, including data on toxicity, flammability, and reactivity. Reference material on hand also provide details on countermeasures to be used.
- Using on-site meteorological data provided by the APC Agency field crew, or as a substitute, data from the cooperating National Weather Service station, the APC Agency may be able to delineate the "exclusion area" for which significant hazardous conditions are predicted.

7.4 THIRD STAGE ALERT: EMERGENCY ACTIVATION

7.4.1 Sequence of Activity

When the report of an accidental episode has been verified, the Chief Operations Authority may declare a Third Stage ALERT if any of the following conditions apply:

1. Hazardous material is being released into the atmosphere in substantial amounts for which immediate and possibly massive countermeasures may be required.
2. Some casualties have been reported, and a threat to other persons is imminent, such that wholesale evacuations may be urgently needed.

3. The hazardous material is known or believed to be highly toxic, flammable, corrosive, or explosive.
4. A First Stage ALERT with Partial Activation, or a Second Stage ALERT with Full Activation that has been in effect appears to be inadequate for restoring normal conditions.

The Governor of the State or designated alternates to whom special emergency authority has been delegated in his absence, may decide to take over the post of Chief Operations Authority, in order to expedite emergency actions for which resources on hand still appear inadequate, e.g., special assistance from adjoining States or the Federal Government.

Manning, Sequence of Activity, and Emergency Information Sources described in 7.3, Second Stage ALERT, apply also to the Third Stage ALERT. The Third Stage ALERT differs only in requiring larger amounts of additional material and manpower. Furthermore, some functions and team members that often remain on call during a Second Stage ALERT will most likely be activated during a Third Stage ALERT.

7.5 CHECK LIST WHEN AN EPISODE OCCURS

7.5.1 Priority Actions

Check, as Applicable

First Contingency Plan participants on the scene immediately assume overall control until relieved by designated Chief Operations Authority or On-Scene Commander ____

In accordance with SOP, the COA will:

- Mobilize public safety services ____
- Quickly determine nature and extent of disaster ____
- Alert the American Red Cross ____
- Alert others who may be needed ____

Activate Emergency Operations Center (7.5.2, below) ____

Initiate public information activities (7.5.3, below) ____

Survey the disaster scene and estimate the situation ____

Insure adequate crowd and traffic control measures ____

Notify the following of the general situation:

- Governor, Mayor, County executive, as appropriate ____
- Civil Defense Area Organization, if applicable ____
- Disaster Services Coordinator ____
- State Disaster Office ____

Announce instructions or restrictions on procuring mutual aid or assistance from outside sources (7.5.4, below) ____

Exercise emergency authority if necessary (7.5.5, below) ____

7.5.2 Emergency Operations Center

Activate and man ____

Check, as Applicable

Insure adequate communications with:
- On-Scene Commander ____
- Red Cross and other disaster services ____
- Participating Support agencies ____

Orient key personnel and issue initial instructions:
- Confirm emergency assignments; stress teamwork ____
- Announce primary tasks and stress government responsibility to:
  - Save lives and property ____
  - Keep the public informed (7.5.3, below) ____

Start and maintain activity logs indicating time and nature of information received, messages received and sent, actions taken, instructions issued, and requests and reports made ____

Develop the situation and anticipate needs:
- Collect and evaluate situation reports ____
- Identify and anticipate critical problem areas ____
- Compare needs to available resources ____
- Determine if assistance may be needed (7.5.4, below) ____

Insure adequate manning of EOC:
- Continuously, 24 hours per day, if necessary ____
- Overlap briefings of relief personnel ____

7.5.3 Public Information

Promptly establish a central information service to:
- Answer public inquiries ____
- Verify data with services concerned ____
- Provide liaison with and facilities for news media ____
- Coordinate releases through news media ____
- Assist news media in obtaining information ____

Meet with news media representatives and
- Establish mutual cooperation in public interest ____
- Stress necessity of authenticating facts before release ____

Check, as Applicable

In releasing information to the general public:

Present a factual picture of the situation and operations ____

Stress teamwork among the disaster services ____

Issue clear, simple instructions for the public e.g.:

Stay away from disaster area ____

Monitor local radio or TV for information ____

Use telephone only for emergency calls ____

Release names of disaster dead only through designated Chief Medical Examiner-Coroner ____

Issue information or instructions as the situation requires: evacuation of danger areas, location of mass care centers, water supply, use of highways, etc. ____

7.5.4 Mutual Aid and Other Assistance

First, use own resources, the Red Cross and other emergency, welfare or contract services to the maximum. If available resources appear inadequate:

Alert agencies from whom assistance may be requested ____

Coordinate and determine actual assistance needed ____

Make specific requests to appropriate sources ____

7.5.5 Governing Authority

Issue local disaster proclamation, when warranted ____

Request State/Federal disaster proclamations if necessary ____

Impose emergency curfew, if necessary ____

Suspend liquor sales, if advisable ____

Forbid verbal contracts, authorize use of predrawn standard contracts and establish or confirm authority for signing contracts ____

If the president has declared a "major disaster" and Federal assistance under Public Laws 81-875 and 89-769 is involved, adopt appropriate resolutions (see OEP Circular 4000.5B, Natural Disaster Assistance Program)

Check, as
Applicable

For financial assistance, designating the individual authorized to act for the jurisdiction. See sample: OEP Circular 4000.5B, Page 23 _____

For direct assistance, requesting OEP to arrange emergency work. See sample, OEP Circular 4000.5B, Page 47 (original and 4 copies to Civil Defense office) _____

7.5.6 Keep Records

Insure that accurate records are maintained to ducument the disaster situation, its effects, actions taken and reasons therefor, including:

Chronological staff and service activity logs _____
Estimates of damage _____
Resources employed _____
Contracts made _____
Mutual aid or assistance requested/provided _____
Financial expenditures and obligations _____
Photographs _____

7.5.7 Continuing Direction and Coordination

The situation may change rapidly until it is stabilized. Be alert and flexible; expect the unexpected. Utilities may be disrupted suddently, partially or gradually; fires or explosions may be triggered. Incorrect reports may cause panic or diversion of needed resources

Maintain a firm position of leadership _____
Direct and coordinate inter-service activities _____
  Depend on service chiefs and key personnel _____
  Delegate tasks and avoid minor details _____
Hold staff conferences, as necessary _____
  Insure that objectives are being reached _____
  Insure that resources are correctly applied _____
  Analyze current and potential problem areas _____
Maintain liaison and coordinate with other jurisdictions involved _____

Check, as Applicable

Verify reports of new or worsening situations ____

Adjust resources to most critical needs ____

Keep disaster services, other agencies and the public informed ____

7.6 CHECK LIST FOR POST-EPISODE RECOVERY AND REHABILITATION

7.6.1 Safety and Security

Continue emergency and relief operations ____

Maintain surveillance of disaster area ____

Maintain controlled access to disaster area ____

Initiate public health and building inspections ____

Permit reoccupation of areas only after safety is verified and other inspections are completed ____

7.6.2 Public Information and Assistance

Continue to keep the public informed ____

Establish a center where individuals and business representatives can obtain information on claims, rehabilitation and financial assistance (Red Cross, Small Business Administration, etc.) ____

7.6.3 Administrative Matters

Continue activity logs until disaster is officially declared terminated ____

Maintain complete and factual records (they may be needed for state or Federal assistance) ____

7.6.4 Return to Normal

As soon as they become marginal or unnecessary:

Release volunteer help and outside assistance ____

Phase down emergency services ____

Return equipment and supplies ____

Check, as
Applicable

Withdraw restrictive ordinances and resolutions ____

Reduce or remove restrictions on disaster area ____

7.6.5 Reports

Report, by month, any non-budgeted disaster or emergency costs to the appropriate State office (Emergency Services or equivalent) ____

Analyze disaster operations objectively and

  Prepare a summary report for official records ____

  Initiate appropriate measures to improve readiness ____

8. COMMUNICATIONS*

Most communications between established locations (EOC to Public Health Service, APC agency, Red Cross, Governor's office, etc.) will utilize commercial telephone lines. Unlisted numbers may be reserved for emergency purposes of this type. Several large urban areas may even be operating emergency teletype of facsimile networks. However, for the two-way communications between the Chief Operations Authority and the On-Scene Commander, and between the On-Scene Commander and the variety of Response Team units deployed about the accidental episode site, radio is the best medium.

8.1 EMERGENCY RADIO NETWORK

The radio network established for the State Disaster Plan, in accordance with Public Law 91-606, may provide for usage of one or more of its frequency bands for local Contingency Plan communications. If none is available, the Contingency Plan Organization should apply to the Federal Communications Commission for a dedicated frequency assignment. Any Contingency Plan participant may then operate base and/or mobile transmitted on this band subject to the following conditions:

1. The user purchases (or leases), installs, and maintains the installation.
2. Each transmitter must be leased to the licensee, the Disaster and Civil Defense Commission, by the user.
3. The user agrees to observe applicable FCC regulations and Contingency Plan procedures.

Any person, agency, or company may operate a receiver on the above frequency without need for leasing or licensing.

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*NOTE: The following section has been adapted from the Channel Industries Mutual Aid (CIMA) Manual, September 1961. A radio frequency of 47.54 MH is assigned to the City of Houston, Texas Department of Municipal Defense for use by the CIMA organization. Applications for frequency assignments should be filed with the Federal Communications Commission.

Since the need for the radio network would be greatest in event of telephone failure, and since conditions leading to telephone failure might well cause power failure also, all units should have alternate emergency power sources.

8.2 NETWORK DISCIPLINE AND "NET CONTROL" STATION

All stations in the radio network transmit and receive on the same frequency. Therefore, all calls made are received by all units on the system. An orderly manner of operation is necessary to prevent confusion. For this reason, the EOC station must always act as "Net Control." So that operators will be familiar with the proper procedure, frequent drills are necessary. In the event of any actual alert call as described under "Types of Calls", the station originating the alert will automatically become the "Net Control" until the EOC station, or another station designated by the Chief Operations Authority, assumes the position.

Under network operation, no station in the system may originate a call to or answer a call from, any station in the network except the "Net Control" unless granted specific permission to do so by the "Net Control."

8.3 RULES AND REGULATIONS

In addition to "network discipline" outlined above, the following rules must be observed if the full utility of the system is to be realized and violations of Federal Communications Commission rules are to be avoided.

1. This communications system may be used only in the event of an emergency or for scheduled training drills as indicated in the "Classification of Calls" section. The system may never be used for routine business affairs.
2. All calls, announcements, and conversation must be brief as possible consistent with good intelligibility. With 20 or more "party-line" stations, air time is valuable.

3. An operator of a station signifies that he has temporarily finished transmitting and is awaiting a reply by use of the word "over" at the end of his transmissions and concluded his message, he uses the word "out" to signify that he is through and does not expect a reply. Always wait until both or all stations engaged in communications use the word "out" before you originate a call, unless you are the station being called and a reply from you is expected.
4. Always listen before transmitting. Never interrupt communications between other stations unless you have a real and immediate emergency. This frequency might not be assigned exclusively to this system and it is possible that licensees of the same frequency in other areas may be heard at times. When this occurs, every effort, except in the event of a genuine emergency, should be made to avoid interference with the other system.
5. Call signs officially assigned by the FCC must be used at least once, either at the beginning or end of a series of transmissions. At other times location codes and agency names may be used.
6. No profane or obscene language may be transmitted over the communications system. This is prohibited by federal law.
7. Only persons so authorized by competent authority at each agency may use the communications system.
8. A complete log book must be maintained at each base station. An entry must be made when each shift operator goes on and off duty and when another base station is contacted. At intervals not to exceed six months measurements of the transmitter frequency, modulation deviation and power input must be made and the results entered in the log book. These measurements should be made, and the log book entries signed, by a qualified technician holding a Second Class Radiotelephone or higher class license.

9. All pertinent rules and regulations of the Federal Communications Commission, as well as the instructions of the licensee and his duly authorized representative must be observed at all times.

8.4 WEATHER REPORTS

The radio network operated by the State Highway Police usually schedules routine weather reports, and broadcasts of special weather reports and warnings as they become available. Reports are usually received at Police Headquarters via telephone or direct teletype from the National Weather Service. These weather bulletins do not serve the purposes of on-scene meteorological observations, but they are useful to the extent that they describe the general weather picture in which responsive action to an accidental episode must be executed.

8.5 EMERGENCY RADIO PROCEDURES

8.5.1 Daily Drill

"Net Control" will announce:

CALL SIGN
NAME OF AGENCY
LOCATION NUMBER
DAILY DRILL

"Net Control" will then call all stations by name in sequence, with each station replying with the information above.

"Net Control" will respond to each answering station with:

NAME OF ANSWERING COMPANY
and one of the following:
RECEIVED LOUD AND CLEAR
RECEIVED WEAK or
RECEIVED CUTTING OUT

This information should be entered in the "Net Control" station log book.

After all stations have been called, "Net Control" will then announce:

STAND BY FOR WEATHER REPORT
GO AHEAD
KPDQ 969 (use appropriate identification)

Upon completion of the weather report, "Net Control" will announce the daily drill is over and proceed to close the net.

8.5.2 Standby Alert

Station originating report of an accidental episode will announce:

CALL SIGN
NAME OF AGENCY
NAME OF OFFICIAL AUTHORIZING THIS REQUEST
LOCATION NUMBER
STANDBY ALERT
(Repeat the above twice)

Describe briefly the reported nature of the emergency and advise Operations Duty Officer that validation is awaited.

Sign off by announcing:

CALL SIGN
NAME OF AGENCY
NAME OF OFFICIAL AUTHORIZING THIS REQUEST
LOCATION NUMBER
STANDBY ALERT
OUT

8.5.3 Assistance Call

Station originating call (Net Control) will announce:

CALL SIGN
NAME OF OFFICIAL AUTHORIZING THIS REQUEST
LOCATION NUMBER

ASSISTANCE CALL
(Repeat the above twice.)

Describe nature of emergency and type of assistance needed.
Request that locations sending assistance reply as soon as possible.
Then call and get a reply from at least one other station as a check to make sure call has been received.

Sign off by announcing:

CALL SIGN
NAME OF OFFICIAL AUTHORIZING THIS REQUEST
LOCATION NUMBER
ASSISTANCE CALL
OUT

Advise as soon as possible when assistance call is over.

8.5.4 All-Out Call

Station originating call will announce:

CALL SIGN
NAME OF AGENCY
NAME OF OFFICIAL AUTHORIZING THIS REQUEST
LOCATION NUMBER
ALL-OUT CALL
(Repeat the above twice.)

Describe nature of emergency.
If at all possible, state specific types of assistance known to be needed.
Then call and get a reply from at least one other station as a check to make sure call has been received.

Sign off by announcing:

CALL SIGN
NAME OF AGENCY
NAME OF OFFICIAL AUTHORIZING THIS REQUEST
LOCATION NUMBER
ALL-OUT CALL
OUT

As soon as actual requirements can be determined, issue a second call to request specific types of assistance required.

8.5.5 Response to Calls

Operators receiving calls should notify appropriate officials according to prearranged plans. Responding team members should instruct their operators to advise the EOC what type of assistance is being dispatched and, if possible, the estimated time of arrival.

8.6 MOBILE RADIOS

8.6.1 Vehicles

All vehicles in use by Contingency Response Teams should be equipped with two-way radios that can operate on the emergency network bands. Broadcast procedures are as described above.

8.6.2 Hand Sets

Portable radios ("walkie-talkies") used for communication among on-scene individuals will not use an emergency network band; they will be operable only on available citizen's bands.

8.7 EMERGENCY NOTIFICATION CHECK LIST

It will be necessary to reach many people quickly. Normal telephone service may fail, or key personnel may be away from their offices or homes.

Prescribe a telephone fan-out system ____

  Base it on a 24-hour office or service ____

  Include alternate key personnel ____

Prescribe alternate system of notification ____

Instruct key personnel to report promptly when information of a local disaster is received by radio, TV or other means ____

Test and improve the emergency notification system ____

APPENDIX C

CASE HISTORIES AND STATISTICS ON ACCIDENTAL EPISODES

C.1. CASE HISTORIES

The following are typical reports of accidental episodes that have occurred in recent years. Accounts of stationary source episodes are taken from the Manufacturing Chemists' Association three-volume compilation entitled "Case Histories of Accidents in the Chemical Industries." Names and dates are not given in these accounts. Reports of mobile source episodes are condensed from press stories or from official government post-accident analyses. A typical press report is shown in Figure C-1.

Top of the news

FIREMEN BATTLE chemical tank car blaze after derailment in Houston

VCM tank cars explode

Two tank cars carrying vinyl chloride monomer (VCM) exploded and burned last week when 18 cars of an 83-car Missouri Pacific freight train derailed in Houston. One fireman was killed and 36 other persons, including several newsmen and photographers, were injured. The VCM was being transported from Dow Chemical's Oyster Creek, Tex., plant to Union Carbide at Texas City. The two explosions, an hour apart, produced a fireball, which charred houses 600 yds. away.

Dow Chemical said there were six VCM cars in the train and that only two were affected. Other cars contained acetone, butadiene, caustic soda, formaldehyde (one car each) and fuel oil (all the rest). The accident will not substantially affect Carbide's supply of VCM, since its inventories and alternative sources are sufficient.

The U.S. Dept. of Transportation's Office of Hazardous Chemicals in cooperation with the Federal Railroad Administration, has begun an investigation into the mishap. One fire truck was destroyed and a residential area was evacuated. Railroad crews had been working in the area where the derailment occurred before the accident.

A Dow spokesman says there were 12 cars carrying Dow's products, including the 48,000-gal. VCM tank cars, but none of them belonged to Dow. The company does not know what caused the accident. The cars of several other chemical companies also were involved.

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Figure C-1. Typical Press Report of an Accidental Episode

Acetaldehyde

An explosion occurred in a pilot plant operation where a reaction was being conducted involving acetaldehyde.

The equipment included an oxidation column, acetaldehyde supply tank, and nitrogen and oxygen supply lines. The explosion occurred in the 55-gallon supply tank. In operation, the system was first purged with nitrogen. Acetaldehyde was supplied to the column with nitrogen pressure on the supply tank. The oxidation was conducted by introduction of controlled amounts of oxygen into the column.

The piping was arranged so nitrogen could be used to purge the column and a portion of the oxygen piping. This arrangement did not exclude the possibility of a higher oxygen pressure feeding into the nitrogen lines in case of leaking valves or improper operation of the valves.

The operator noticed a leak in the acetaldehyde drum. Supervision requested the operator to shut down the operation. The explosion occurred a few minutes later resulting in eventual death of four employees and burns to two others.

The investigation of the accident leads to the assumption that oxygen leaked into the acetaldehyde drum through the nitrogen purge line and valve.

Ethylene Oxide and Ammonia

A feed storage tank containing several thousand gallons of ethylene oxide exploded killing an employee, injuring a number of others and causing extensive property damage.

Process equipment and buildings in the vicinity of the explosion were either destroyed of severely damaged. The blast caused destruction throughout the plant, and to buildings in the neighborhood.

The explosion occurred in an ethanolamine manufacturing area which had been in operation for several years. In the process, ammonia and ethylene oxide were fed into a horizontal, tubular reactor using pumps which were interlocked to assure the desired proportion of reactants. Immediately prior to the explosion we experienced unusual variations of pressure in the unit and there are indications that during a period of high pressure, unreacted ammonia got back into the process feed tank containing ethylene oxide, resulting in a chemical reaction which caused the explosion.

Property damage is estimated at several million dollars.

Chlorination Explosion -- Eight Lives Lost

A chlorinator exploded, without warning, killing eight employees and causing property damage loss of approximately one million dollars.

The accident occurred in the chlorination step of methyl parathion production. The batch under process was only partially chlorinated at the time of the explosion.

The chlorine feed valve was closed manually but it is probable that prior to this it was wide open for approximately one-half hour, while the temperature controller was calling for more chlorine. This would have resulted in adding chlorine faster than a normal rate at this stage of the chlorination. Subsequent research work has shown that this amount of chlorine would have raised the temperature of the batch rapidly, since the agitator had been stopped and brine shut off while the faulty thermocouple was being replaced.

On the basis of research work, when high temperatures are reached, and almost instantaneous decomposition occurs accompanied by the type of pressure release which was experienced. The chlorinator released this pressure build-up by blowing its cover through the roof.

Immediately following the explosion, chlorine and ammonia from ruptured feed lines united to form gaseous ammonium chloride. Since the plant management feared that more toxic fumes might be released, the state police were asked to warn 1500 residents in nearby homes. The police used loudspeakers on their cars and alerted the area to the possible danger.

The plant is a member of the local Industrial Emergency Planning Council. This emergency plan went into action immediately after the explosion. Within 10 minutes, all access roads into the area were blocked by state police, city police and civil defense volunteers. Five minutes later ambulances began arriving.

All IEPC member plants went on a stand-by basis, prepared to send in rescue material and emergency crews. Two neighboring chemical plants sent their plant nurses and oxygen masks for rescue operations.

Company headquarters sent to the scene production officials, the company medical director, and a member of the public relations staff. Local radio, TV, and newspaper reporters were kept fully informed of everything connected with the disaster, which was an important factor in keeping news as favorable as possible in a disaster of this type.

Sulfides in Acid Sewer

The accident occurred in a large chemical plant at which operations include the production benzyl polysulfide. Normally, liquid sodium sulfhydrate is delivered to the plant in large tank cars and transferred through completely enclosed pumping systems to a 5,000 gallon storage tank. From this tank the sulfhydrate is moved further through another closed pumping system to a mixing tank containing sodium hydroxide to form sodium sulfide solution for later use in the manufacturing process. Hydrogen sulfide is not formed at any stage of the process and has never been a problem. The sewer drains in the area where this process takes place connect with the general sewage system of the plant. Ordinarily, wastes from other processes in the plant render the sewer contents somewhat acid.

On the morning of the accident, the pump leading from the storage tank which contained sodium sulfhydrate to the mixing tank containing sodium hydroxide was started. When the gauge did not show adequate flow, live steam under 120 pounds pressure per square inch was applied to the pump to clear the lines. The housing of the pump broke and the adjacent pipe leading from the sulfhydrate tank promptly ruptured. Liquid sodium sulfhydrate poured onto the ground and into a nearby sewer where it immediately reacted with the acid sewage, releasing excessive amounts of hydrogen sulfide gas from several sewer openings with a radius of 150 feet. Some of the gas was spread further by natural air movement so that a faint odor of the hydrogen sulfide gas was detectable 500 feet downwind from the damaged pump.

Evacuation and rescue operations began immediately. Within a few minutes the nature and source of the exposure were recognized, and several tons of caustic were dumped into the sewer to terminate the generation of the hydrogen sulfide gas.

Vinyl-Chloride

Glendora, Miss. - On September 11, 1969, an Illinois Central freight train engineer applied the brakes in full emergency in an attempt to avoid striking a pedestrian. The 149-car train buckled at the 108th car. The resulting derailment involved 15 cars, including eight tank cars loaded with vinyl chloride. The cars separated in the derailment and the coupler of one of the cars punctured one of the tank cars, spilling its contents on the ground.

Initially, the breeze dispersed the vapor; however, the vapor accumulated in low places and was ignited by an unknown source. The ignition was followed by several explosions.

An estimated 17,000 to 21,000 persons were evacuated because of an alleged danger from phosgene.

The following morning a fire-impinged tank car of vinyl chloride exploded violently. Buildings, automobiles, and equipment were destroyed and damaged by fire.

The derailment was caused by the buckling of the underframe of the 108th car when the engineer made a full emergency brake application. The car buckled because of excessive and uncontrollable compression in the train which developed when the full emergency brake application created greater braking force on the head of the train than on the rear. The absence of interlocking couplers and other means of preventing separation and jackknifing allowed the cars to jam up together.

Liquid Petroleum Gas

Laurel, Miss. - On January 25, 1969, 15 tank cars of liquified petroleum gas in a Southern Railway Train were derailed. A wheel on the 62nd car broke and caused this car and 14 behind to derail. Damage to the cars caused them to burst into flame and/or explode. Residents were evacuated over an area of 100 square blocks. Fifty-four homes were destroyed and 1,350 more were damaged. Schools, churches and businesses were also damaged. Two fatalities, 33 hospitalizations and numerous minor injuries resulted.

The wheel was in a tread-worn hollow condition. Lateral loading of the wheel due to the out-of-level condition of the track crossing caused a fracture in a roughly machined area.

Anhydrous Ammonia

Crete, Neb. - On February 18, 1969, a CB & O freight train had a number of its cars derailed as it entered Crete. The derailed cars struck standing cars on sidings next to the main track. A tank car was completely fractured by the derailed cars and released 29,200 gallons of anhydrous ammonia into the atmosphere. A gas cloud was formed and, due to the weather conditions, blanketed the surrounding area for a considerable time. Six people were killed and 53 were injured as result of exposure to the cloud of ammonia. The derailment was caused by track having alignment and surface deficiencies.

Propane Gas

A frameless type MC-330 tank trailer was transporting 6876 gallons of propane gas as liquid under pressure. The tank ruptured and its cargo of propane exploded, resulting in 10 deaths and 17 injuries. Property damage was estimated to exceed $200,000. Nine dwellings, one church, one garage, one house trailer, six outbuildings, two school buses, four trucks and five passenger vehicles were totally destroyed and two other houses were damaged. The accident occurred on a county highway approximately 560 feet northeast of the center of town. It appears that the vehicle tipped, or was at least partially out of control just prior to the rupture, which occurred at a weld. The sharp turning of the vehicle back to the right side of the road at the bottom of the hill may have applied an additional stress factor to the weld in question.

Ethylene Oxide

Dunreith, Ind. - On January 1, 1968, a westbound freight had its 88th car derailed by a broken rail. The derailed empty tank car became disengaged from its trailing truck when it struck the crossing boards at a grade crossing. One or more cars collided with cars carrying hazardous materials in an eastbound train on an adjacent track. A large-scale fire ensued followed about 45 minutes later by a violent explosion of a tank car of ethylene oxide. The entire population of Denreith was evacuated.

The fire and explosion destroyed a cannery, several residences, and businesses in the vicinity. Firefighters were hampered by a lack of information regarding these type materials and the necessary equipment to extinguish the resulting fire.

A car of acetone cyanohydrin, a powerful poison which was punctured and set afire became the source of cyanides contaminating a stream and causing the loss of several farm animals.

Inadequate track maintenance resulted in an unsupported rail joint which caused a break in the rail. Lift-off design of center-pin connection allowed truck to separate from the derailed car.

Anhydrous Ammonia

Creve Coeur, Ill. - Shortly before midnight on August 1, 1961, a four inch discharge hose on an anhydrous ammonia barge ruptured, necessitating the evacuation of 13,000 people from the southern suburbs of Peoria, Illinois.

Chlorine

Toxic chlorine fumes escaped near a District Heights Md., swimming pool and sent 36 persons to hospitals for treatment of breathing problems. The seepage occurred at the private swimming pool of Olde Towne Village, a complex of apartments and row houses.

Seepage of the pungent, colorless gas, was caused by an improper mixing by the pool's lifeguard of chlorine powder and muriatic acid, a substance used for washing the poolside concrete.

Prince George's Hospital had to declare a disaster and call in additional nurses and doctors to treat 34 persons, all but eight of them children, who came to the hospital with "respiratory problems."

Fumes began to waft through the area when a lifeguard was preparing the greenish-blue dry chlorine in a 50-gallon plastic for siphoning into the pool inside a brick shed about 15 feet away from the pool. The mixing of the chlorine with the concrete-cleaning acid was apparently a mistake. The fumes spread only about 30 feet from the pool and did not seep into surrounding houses. The fire company was able to suppress the fumes in a half-hour.

First attempts to suppress the fumes by diluting the mixture in the plastic drum with water and setting up a "rain curtain" to vaporize the fumes were unsuccessful. Firemen finally eliminated the fumes by waving rags soaked with household ammonia over the plastic drum.

Hydrogen Sulfide

Hydrogen sulfide gas evolved during several reactions is absorbed in caustic solution scrubbers. The resulting sulfhydrate solution from the scrubbers is sometimes discharged to the drainage ditch outside the building. Improper scheduling of the "ditching" permitted the sulfhydrate and a solution with approximately 8% hydrochloric acid content to mix in this ditch. Hydrogen sulfide fumes were evolved for a period of from two to three minutes. Operators from the building had been evacuated as a precautionary measure when a slight detection of a gas odor was noticed. Two employees entered the open area where fumes were being generated. Others affected were assisting in rescue efforts. Of the twenty-two men exposed seven were overcome to the extent that resuscitation was necessary. One died and three others required hospitalization.

Hydrogen Sulfide Gas

Eleven company employees were exposed to hydrogen sulfide gas; 2 died; 6 were hospitalized and 3 received first aid treatment at the hospital. In addition, a non-company ambulance driver died while attempting to revive the striken employees.

Three pipe fitters were attempting to install a blind in a 20" line on an alkylation depropanizer tower. They were working on a permanent steel platform about 14 feet above the ground. Two of the men were overcome from the gas and later died. The third pipe fitter was able to get down the ladder and inform the unit operators of the problem. In the rescue attempt, the other employees were exposed to the gas.

The source of the hydrogen sulfide gas was a hydrogen sulfide absorbing system on a catalytic cracking unit. The gas was inadvertently released into a low pressure vent gas system and during the depressuring operation reached the depropanizer tower.

Vinyl Chloride

On August, 1961, an explosion broke out at the Minamata Plant of the New Japan Nitrogen Fertilizer Co., claiming four lives and injuring ten people in or around its premises.

The plant produces varieties of chemical fertilizers and plastics including polyvinyl chloride, and the explosion occurred in the vinyl chloride polymerization plant, a building containing 18 pressure vessels, in which polyvinyl chloride is produced from vinyl chloride monomer.

A foreman and three employees set to work to discharge the contents according to directions from the controller's room but in error they opened vessel No. 4 instead of No. 3. The gaseous vinyl chloride monomer just in the process of polymerization burst out of the vessel, filled the room and shortly afterwards exploded.

The foreman was found dead at the top of No. 3 tank and one of the two workers at the bottom was dead on arrival at the hospital. An employee in the controller's room died instantly and another worker in the burner plant, a building next to the polymerization plant, died after two days. Within the premises of the factory, 8 additional persons were injured, most of them not seriously, and outside the factory two persons were injured slightly by flying glass.

Inside the building, the steel frame was dented or buckled by the shock of the explosion; iron floor plates in particular were seriously damaged, some of them severed, others blown away. Glass panes on the doors and the windows were blown off.

C.2 STATISTICS ON ACCIDENTAL EPISODES

At this time there appear to be no available statistics on accidental episodes by specific commodity or even family of commodity. An exhaustive search in the files of all known repositories of data on the subject has uncovered no statistical analysis that gives the following data and combined probabilities in detail for each chemical:

1. Total number of accidental releases: stationary and mobile
2. Total weight of material lost: stationary and mobile
3. Number of mobile accidents per number of hauls
4. Weight of material lost in transit per weight hauled
5. Geographical distribution of accidents
6. Number of accidents and weight of material lost by geographical distribution
7. Accident frequency and weight of lost material per type of carrier, as compared with number of hauls and total weight of material hauled by each type.
8. Breakdown by primary cause of accident (collision, etc.)
9. Breakdown by material release mechanism (rupture, valve malfunction, etc.)

At present, the only report found to have a breakdown even remotely resembling this type is the annual Engineering and Safety Bulletins issued by the National Tank Truck Carriers, Inc. Exhibit C-1, Tables I-IV reproduced from the report issued in December 1970 for the year 1969, are typical of the available statistics. Exhibit C-2 shows a blank form that is now required by the Department of Transportation Offices of Hazardous Materials, which began a new data bank on accidental episodes in January 1971. None of the forementioned data items is as yet available, but should be after at least a year's worth of reports are analyzed.

FOR-HIRE TANK TRUCK ACCIDENTS REPORTED TO THE DEPARTMENT OF TRANSPORTATION DURING 1969

TABLE I
DISTRIBUTION OF TYPES OF ACCIDENTS

Type of Accident	Number of Accidents	Fatalities	Injuries	Property Damage
Collision With:				
Passenger Car	1632	54	973	$2,169,148
Other Truck	455	12	220	1,154,814
Train	38	1	10	140,649
Fixed Object	215	1	36	467,666
Pedestrian	28	8	20	25
Animal	35	0	5	73,017
Misc. Objects	35	3	25	46,840
Jackknife	161	0	17	255,961
Ditched	165	2	78	740,936
Fire Only	0	0	0	0
Miscellaneous	68	0	28	75,291
Combination Ditch/Overturn	142	2	80	879,026
Cargo Tank Punctured	1	0	0	1,024
Explosion	0	0	0	0
Cargo Tank Ruptured	0	0	0	0
Hose Failure	2	0	0	1,380
Cargo Spilled	12	0	1	13,198
Overturned	119	1	44	744,214
Valve Failure	2	0	2	0
Dome Cover Failure	0	0	0	0
Loading or Unloading	3	0	0	8,600
TOTAL	3113	85	1539	$6,771,789
SECONDARY RESULTS				
Passenger Car	8	0	10	
Other Truck	4	0	9	
Fixed Object	58	1	32	
Jackknife	106	0	53	
Ditched	21	1	9	
Miscellaneous	1	0	1	
Combination Ditch/Overturn	12	0	13	
Cargo Tank Punctured	1	0	0	
Cargo Tank Ruptured	1	0	1	
Cargo Spilled	8	0	3	
Overturned	19	0	14	

Exhibit C-1, Table I

TABLE II
DISTRIBUTION OF ACCIDENTS BY EXTENT OF PROPERTY DAMAGE

Type of Accident	Less Than $500	$500 to $1000	$1000 to $5000	Over $5000	Accidents	Property Damage	Average Property Damage
Collision With:							
Passenger Car	641	466	446	79	1632	$2,169,148	$1,329
Other Truck	129	119	148	59	455	1,154,814	2,538
Train	6	10	14	8	38	140,649	3,701
Fixed Object	72	55	61	27	215	467,666	2,175
Pedestrian	28	0	0	0	28	25	1
Animal	11	9	11	4	35	73,017	2,086
Misc. Objects	16	10	8	1	35	46,840	1,338
Jackknife	29	40	87	5	161	255,961	1,590
Ditched	13	28	70	54	165	740,936	4,491
Fire Only	0	0	0	0	0	0	0
Miscellaneous	35	14	15	4	68	75,291	1,107
Combination Ditch/Overturn	4	12	62	64	142	879,026	6,190
Cargo Tank Punctured	0	0	1	0	1	1,024	1,024
Explosion	0	0	0	0	0	0	0
Cargo Tank Ruptured	0	0	0	0	0	0	0
Hose Failure	1	0	1	0	2	1,380	690
Cargo Spilled	7	3	1	1	12	13,198	1,100
Overturned	6	8	50	55	119	744,214	6,254
Valve Failure	2	0	0	0	2	N/A	N/A
Dome Cover Failure	0	0	0	0	0	0	0
Loading or Unloading	1	1	0	1	3	8,600	2,867
TOTAL	1001	775	975	362	3113	$6,771,789	$2,175
	32.2%	24.9%	31.3%	11.6%			

SECONDARY RESULTS				
Passenger Car	2	2	2	2
Other Truck	0	1	2	1
Fixed Object	7	9	29	13
Jackknife	11	17	53	25
Ditched	1	2	13	5
Miscellaneous	1	0	0	0
Combination Ditch/Overturn	0	0	2	10
Cargo Tank Punctured	0	0	1	0
Cargo Tank Ruptured	0	0	0	1
Cargo Spilled	0	2	2	4
Overturned	2	0	8	9

EXHIBIT C-1, Table II

TABLE III
DISTRIBUTION OF ACCIDENTS BY TYPE OF CARGO

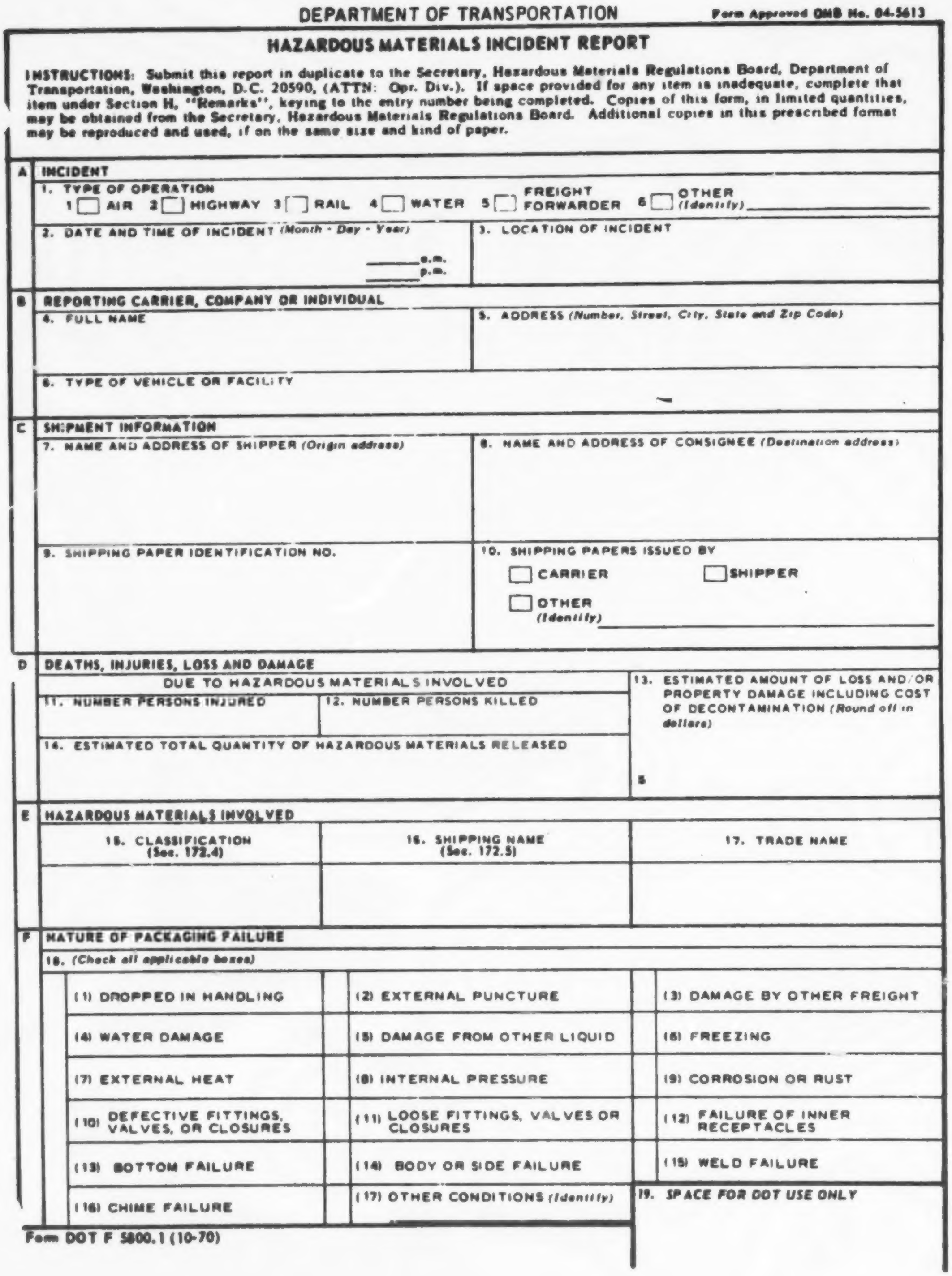
Type of Cargo	Number of Accidents	Percent of Accidents	Fatalities	Injuries	Property Damage	Average Property Damage
Empty	1,331	42.75%	29	704	$2,183,567	$1,640
Casinghead Gasoline	1	.03%	0	1	1,300	1,300

Silicate of Soda	2	.06%	0	0	900	450
Sulphur	19	.61%	2	11	64,440	3,391
Food & Kindred Products	9	.28%	2	7	36,175	4,019
Corn Starch, Syrup, Oil, Sugar & By- Products (Wet Process)	65	2.08%	5	34	160,490	2,469
Whiskey	1	.03%	0	0	1,000	1,000
Unidentified	1	.03%	0	1	950	950
Cottonseed Oil	2	.06%	0	1	2,893	1,446
Soybean Oil (Crude & Refined)	8	.25%	2	3	34,899	4,362
Vegetable & Nut Oils & By-Products, Except Cotton Seed & Soybean	11	.35%	0	4	37,101	3,372
Shortening, Table Oils, Margarine & Other Edible Fats	7	.22%	0	2	11,804	1,686
Sodium Silicate	5	.16%	0	3	7,011	1,402
Industrial Gases (Compressed & Liquefied)	12	.38%	0	6	46,207	3,850
Alum, Catalyst, Uran	8	.25%	0	4	18,630	2,328
Misc. Industrial Organic Chemicals	117	3.75%	8	66	337,933	2,888
Alcohols	16	.51%	0	7	45,590	2,849
Sulphuric Acid	29	.93%	1	20	58,683	2,023
Plastic Materials & Synthetic Resins, Synthetic Rubber & Fibers	55	1.76%	4	45	116,146	2,111
Soap & Other Detergents Except Specialty Cleaners	9	.28%	0	5	32,985	3,665
Ink, Paint & Varnish	10	.32%	0	4	27,919	2,791
Fertilizer	51	1.63%	6	20	177,755	3,485
Unidentified	1	.03%	0	1	4,800	4,800
Misc. Chemical Products	91	2.92%	0	38	210,451	2,312
Benzene & Heptane	3	.09%	0	2	9,400	3,133
Creosote	3	.09%	0	1	3,884	1,294
Products of Petroleum Refining — Gasoline, Jet Fuels, Other High Volatile Petroleum Fuels, Except Natural Gasoline	487	15.64%	9	217	1,228,396	2,522
Fuel Oils & Kerosene	251	8.06%	5	105	662,561	2,639
Lubricating & Similar Oils & Derivatives	7	.22%	0	3	12,102	1,728
Grease & Lubricants	4	.12%	0	4	37,750	9,437
Asphalts	81	2.60%	0	34	253,042	3,123
Refined Products	1	.03%	0	0	1,600	1,600
Liquefied Pet. Gases and Coal Gases	100	3.21%	3	39	346,734	3,467
Unidentified	1	.03%	0	0	1,060	1,060
Cement, Fly Ash, Soda Ash	284	9.12%	8	126	535,967	1,887
Lime	30	.96%	1	21	59,664	1,988
TOTALS	3,113		85	1,539	$6,771,789	$2,175
TOTALS MINUS EMPTY FIGURES	1,782		56	835	$4,588,222	$2,574

TABLE IV
DISTRIBUTION OF ACCIDENTS BY STATE

State	Motor Vehicles Registered	Number of Accidents	Total Damage	Injuries	Fatalities
Alabama	1,887,000	101	$ 269,560	95	3
Arizona	980,000	5	17,875	3	0
Arkansas	1,055,000	32	110,405	16	1
California	11,432,000	70	127,279	16	2
Colorado	1,358,000	8	16,185	2	0
Connecticut	1,688,000	26	44,552	12	0
Delaware	297,000	9	9,400	4	0
District of Columbia	245,000	1	1,000	1	0
Florida	3,812,000	174	385,594	109	7
Georgia	2,473,000	104	176,429	44	7
Idaho	480,000	5	7,010	0	1
Illinois	5,136,000	207	507,518	92	3
Indiana	2,834,000	121	210,447	71	7
Iowa	1,750,000	71	163,007	29	4
Kansas	11,550,000	46	181,482	22	1
Kentucky	1,736,000	57	171,213	34	2
Louisiana	1,720,000	85	131,641	56	1
Maine	506,000	14	29,500	4	0
Maryland	1,787,000	33	91,863	12	2
Massachusetts	2,423,000	26	43,335	8	0
Michigan	4,445,000	85	139,461	45	3
Minnesota	2,185,000	67	133,226	31	2
Mississippi	1,094,000	50	118,612	26	1
Missouri	388,000	60	146,742	26	2
Montana	472,000	21	57,250	5	0
Nebraska	931,000	17	19,841	3	0
Nevada	315,000	2	4,038	0	0
New Hampshire	362,000	4	7,325	1	0
New Jersey	3,448,000	188	299,413	68	2
New Mexico	607,000	40	97,921	22	3
New York	6,534,000	171	329,039	100	3
North Carolina	2,698,000	63	175,706	29	2
North Dakota	421,000	10	56,840	4	1
Ohio	5,631,000	202	495,275	110	6
Oklahoma	1,661,000	37	109,813	22	0
Oregon	1,303,000	14	33,151	5	1
Pennsylvania	5,756,000	246	488,891	112	3
Rhode Island	466,000	7	12,149	4	0
South Carolina	1,310,000	35	95,585	17	0
South Dakota	421,000	14	79,092	4	0
Tennessee	1,985,000	91	140,501	31	2
Texas	6,425,000	239	402,307	120	8
Utah	593,000	19	51,210	8	0
Vermont	214,000	9	18,375	3	1
Virginia	2,121,000	50	149,721	28	2
Washington	2,088,000	37	117,977	14	0
West Virginia	839,000	50	115,354	26	1
Wisconsin	2,082,000	61	91,395	28	0
Wyoming	236,000	12	31,760	4	0
Canada	N/A	5	21,550	5	0
N/A	N/A	12	36,983	8	1
TOTALS	104,702,000	3113	$6,771,789	1539	85

Exhibit C-1, Table IV



DEPARTMENT OF TRANSPORTATION

Form Approved OMB No. 04-5613

HAZARDOUS MATERIALS INCIDENT REPORT

INSTRUCTIONS: Submit this report in duplicate to the Secretary, Hazardous Materials Regulations Board, Department of Transportation, Washington, D.C. 20590, (ATTN: Opr. Div.). If space provided for any item is inadequate, complete that item under Section H, "Remarks", keying to the entry number being completed. Copies of this form, in limited quantities, may be obtained from the Secretary, Hazardous Materials Regulations Board. Additional copies in this prescribed format may be reproduced and used, if on the same size and kind of paper.

A INCIDENT

1. TYPE OF OPERATION
1 ☐ AIR 2 ☐ HIGHWAY 3 ☐ RAIL 4 ☐ WATER 5 ☐ FREIGHT FORWARDER 6 ☐ OTHER *(Identify)* ______

2. DATE AND TIME OF INCIDENT *(Month - Day - Year)*
______ a.m.
______ p.m.

3. LOCATION OF INCIDENT

B REPORTING CARRIER, COMPANY OR INDIVIDUAL

4. FULL NAME

5. ADDRESS *(Number, Street, City, State and Zip Code)*

6. TYPE OF VEHICLE OR FACILITY

C SHIPMENT INFORMATION

7. NAME AND ADDRESS OF SHIPPER *(Origin address)*

8. NAME AND ADDRESS OF CONSIGNEE *(Destination address)*

9. SHIPPING PAPER IDENTIFICATION NO.

10. SHIPPING PAPERS ISSUED BY
☐ CARRIER ☐ SHIPPER
☐ OTHER *(Identify)* ______

D DEATHS, INJURIES, LOSS AND DAMAGE

DUE TO HAZARDOUS MATERIALS INVOLVED

11. NUMBER PERSONS INJURED

12. NUMBER PERSONS KILLED

13. ESTIMATED AMOUNT OF LOSS AND/OR PROPERTY DAMAGE INCLUDING COST OF DECONTAMINATION *(Round off in dollars)*
$

14. ESTIMATED TOTAL QUANTITY OF HAZARDOUS MATERIALS RELEASED

E HAZARDOUS MATERIALS INVOLVED

15. CLASSIFICATION (Sec. 172.4)	16. SHIPPING NAME (Sec. 172.5)	17. TRADE NAME

F NATURE OF PACKAGING FAILURE

18. *(Check all applicable boxes)*

☐	(1) DROPPED IN HANDLING	☐	(2) EXTERNAL PUNCTURE	☐	(3) DAMAGE BY OTHER FREIGHT
☐	(4) WATER DAMAGE	☐	(5) DAMAGE FROM OTHER LIQUID	☐	(6) FREEZING
☐	(7) EXTERNAL HEAT	☐	(8) INTERNAL PRESSURE	☐	(9) CORROSION OR RUST
☐	(10) DEFECTIVE FITTINGS, VALVES, OR CLOSURES	☐	(11) LOOSE FITTINGS, VALVES OR CLOSURES	☐	(12) FAILURE OF INNER RECEPTACLES
☐	(13) BOTTOM FAILURE	☐	(14) BODY OR SIDE FAILURE	☐	(15) WELD FAILURE
☐	(16) CHIME FAILURE	☐	(17) OTHER CONDITIONS *(Identify)*		

19. *SPACE FOR DOT USE ONLY*

Form DOT F 5800.1 (10-70)

Exhibit C-2, page 1

G PACKAGING INFORMATION - *If more than one size or type packaging is involved in loss of material show packaging information separately for each. If more space is needed, use Section H "Remarks" below keying to the item number.*

ITEM			#1	#2	#3
20	TYPE OF PACKAGING INCLUDING INNER RECEPTACLES *(Steel drums, wooden box, cylinder, etc.)*				
21	CAPACITY OR WEIGHT PER UNIT *(55 gallons, 65 lbs., etc.)*				
22	NUMBER OF PACKAGES FROM WHICH MATERIAL ESCAPED				
23	NUMBER OF PACKAGES OF SAME TYPE IN SHIPMENT				
24	DOT SPECIFICATION NUMBER(S) ON PACKAGES *(21P, 17E, 3AA, etc., or none)*				
25	SHOW ALL OTHER DOT PACKAGING MARKINGS *(Part 178)*				
26	NAME, SYMBOL, OR REGISTRATION NUMBER OF PACKAGING MANUFACTURER				
27	SHOW SERIAL NUMBER OF CYLINDERS, CARGO TANKS, TANK CARS, PORTABLE TANKS				
28	TYPE DOT LABEL(S) APPLIED				
29	IF RECONDITIONED OR REQUALIFIED, SHOW	A REGISTRATION NO. OR SYMBOL			
		B DATE OF LAST TEST OF INSPECTION			
30	IF SHIPMENT IS UNDER DOT OR USCG SPECIAL PERMIT, ENTER PERMIT NO.				

H REMARKS - Describe essential facts of incident including but not limited to defects, damage, probable cause, stowage, action taken at the time discovered, and action taken to prevent future incidents. Include any recommendations to improve packaging, handling, or transportation of hazardous materials. Photographs and diagrams should be submitted when necessary for clarification.

31. NAME OF PERSON PREPARING REPORT *(Type or print)*	32. SIGNATURE
33. TELEPHONE NO. *(Include Area Code)*	34. DATE REPORT PREPARED

Reverse of Form DOT F 5800.1 (10-70)

Exhibit C-2, page 2

The National Tank Truck Carriers data have become more comprehensive from year to year since they were first reported about 1956. The categories in current use show data consistency for at least the past three reporting years. Initial inferences may therefore be made from the December 1970 report, as follows:

1. For accidents involving all kinds of cargo (including empty container), the most common cause is collision with another truck or passenger car. The number of cases where malfunction of cargo transfer mechanism (valve, hose, etc.) and structural damage to the container are too few for conclusions to be based on statistical analysis.
2. Most accidents occur with tanks empty. Of the others, it is not practical to determine probabilities for each type of commodity even according to the broad groupage used, because there are no parallel figures on the total number of hauls made without accidents.
3. The states of Illinois, Ohio, Pennsylvania, and Texas (underlined) show the highest number of accidents (all commodities). However, if the number of accidents is divided by the number of motor vehicles registered (assuming this is related to the total number used within the state), Alabama, New Jersey, and West Virginia show the highest ratios, over 5 accidents per 100,000 registered vehicles. All of these states have concentrations of heavy industry.

APPENDIX D

LIST OF INDUSTRIAL MUTUAL AID ASSOCIATIONS

The following was extracted from the "Directory of Industrial Mutual Aid Associations," prepared and published by the Directorate of Procurement and Production (MCPM), Headquarters, Air Force Logistics Command, USAF, Wright-Patterson Air Force Base, Ohio, Robert B. Kahn, Editor, April 1961. An updated directory is reported to be in preparation.

State	Name of Association (F indicates a formal agreement)	Location of Participants
Arkansas	Southwest Power Pool	Little Rock
California	Inter-Refinery Fire Prevention and Disaster Committee of North Contra Costa Counta	Martinez, Oleum, Associated, Pittsburgh, Richmond
	Santa Clara County Industrial Mutual Aid Committee	Los Altos, Mountain View, San Jose, San Francisco, Santa Clara, Sunnyvale
	Tri-District Fire Executives Association	Sacramento
	San Diego Area Industrial Mutual Aid Association	San Diego
Connecticut	Groton Industrial Mutual Aid Association (F)	Groton, New London
Delaware	Greater Wilmington DuPont Mutual Aid Group (F)	Carneys Point, N.J., Newport, Penns Grove, N.J., Wilmington
Florida	Port Everglades Oil and Related Industries Association (Peoria) (F)	Port Everglades
Illinois	Monsanto Industrial Area Mutual Aid Organization	Monsanto
	Tri-Cities Industrial Area Industrial Mutual Aid Group	Madison, Granite City
	East Side Associated Industries (F)	Washington Park

	Lemont Mutual Aid Association	Lemont
	Cicero Manufacturers Assn. Mutual Aid Program	Cicero
Indiana	Refinery Mutual Aid Group	E. Chicago, Whiting
	Eastgate Mutual Aid Association	Indianapolis
	Eastend Mutual Aid Association	Indianapolis
	Westside Mutual Aid Association	Indianapolis
	Southside Mutual Aid Association	Indianapolis
	Henry County Civil and Industrial Defense Association	New Castle
	Richmond Mutual Aid Association	Richmond
	Alcoa	Richmond
	South Bend Industrial Mutual Aid Association	South Bend
Kansas	Industrial Mutual Aid Association of Liberal	Kansas
	Sedgwick County Fire Control Council	Wichita
	Wichita Mutual Aid Association	Wichita
Kentucky	Kyova Industrial Mutual Aid Committee (KIMAC)	Ashland, Ironton, Ohio, South Point, Ohio Huntington, W. Va, Kenova, W. Va.
	Rubbertown Mutual Aid Committee	Louisville
Louisiana	Baton Rouge Mutual Aid System	Baton Rouge, Geismar, Brookhaven, Miss.
	Southwest Louisiana Mutual Aid Association	Lake Charles

	A-1 Area Mutual Aid System	New Orleans, Algiers, Arabi, Avondale, Belle Chasse, Chalmette, Empire, Good Hope, Gramercy, Gretna, Hahnville, Harahan, Harvey, Kenner, LaPlace, Luling, Marrero, Meraux, Metairie, Michoud, Norco, Paradis, Pointe-a-la-Hache, Port Sulpher, St. Rose, Westwego
Maryland	Woodberry Industrial Mutual Aid Association (F)	Baltimore
Massachusetts	North Shore Industrial Mutual Aid Organization	Arlington, Beverly, Boston, Danvers, Lynn, North Andover, Peabody, Salem, Saugau, South Boston, West Lynn
	Springfield Safety Council	Springfield
	Meriden-Wallingford Manufacturers Association	Meriden
	Everett Industrial Mutual Aid Council (EIMAC)	Everett
	Worcester Industrial Mutual Aid Group	Worcester
	Route No. 128 Industrial Mutual Aid Association	Waltham
Michigan	Saginaw Valley Law Enforcement Officers Mutual Aid Pact (F)	Bay City, Flint, Midland, Saginaw
Minnesota	Minneapolis Mutual Aid Program	Minneapolis
	Minnesota Mining & Mfg. Mutual Aid	St. Paul
	Remington Rand Mutual Aid	St. Paul
Mississippi	See Baton Rouge Mutual Aid System under the state of Louisiana	
Missouri	Industrial Mutual Aid Group	St. Louis

New Jersey	Bloomfield Industrial Mutual Aid Council (BIMAC)	Bloomfield
	Carteret Industrial Mutual Aid Council	Carter
	West Hudson Industrial Mutual Aid Council	Harrison
	Linden Industrial Mutual Aid Council	Linden
	Edison Township Mutual Aid Council	Edison, Fords, Iselin, Menlo Park, Metuchen, New Brunswick, Nixon, So. Plainfield, Stelton
	New Brunswick Mutual Aid Council (BIMAC)	New Brunswick
	Pennsauken Industrial Mutual Aid Group (F)	Pennsauken
	Parlin Industrial Mutual Aid Council	Parlin, Sayreville
	Piscataway Township Mutual Aid Council	Middlesex
	Perth Amboy Industrial Mutual Aid Council	Fords, Perth Amboy
	Salem County Industrial Mutual Aid Council (F)	Carneys Point, Penns Grove, Salem County
New York	Consolidated Erie County Civil Defense Organization	Buffalo
	Niagara Industrial Emergency Council	Niagara Falls, North Tonawanda, Wheatfield
	Rochester Industrial Management Council (F)	Rochester
	Onondaga County Industrial Mutual Aid Council (OCIMAC) (F)	Syracuse
	Greater Troy Industrial Mutual Aid Council	Troy
Ohio	Alliance Mutual Aid Organization (F)	Alliance

Akron Mutual Aid Organization	Akron
Ashtabula Township Industrial Mutual Aid Organization (F)	Ashtabula
Barberton Mutual Aid Association (F)	Barberton, Cleveland
Blue Ash, Montgomery and Rossmoyne Civil Defense and Mutual Aid Organization (F)	Blue Ash, Rossmoyne, Montgomery
Mutual Aid Group - Industrial Canton (MAGIC) (F)	Canton, Cleveland
Cleveland Northeast Industrial Mutual Aid Organization	Cleveland
Cuy-New Heights Industrial Mutual Aid Organization (F)	Cleveland, Cuyahoga Heights, Newburgh Heights
Southeast Industrial Mutual Aid Organization (F)	Bedford, Bedford Heights, Cleveland, Maple Heights, Solon, Warrensville Heights
Central Ohio Valley Industrial Emergency Organization (COVIEO)	Marietta, Parkersburg, W.Va. Sistersville, W. Va., South Parkersburg, W.Va., St. Marys, W.Va., Vienna, W.Va. Washington, W.Va., Williamstown, W.Va., Willow Island, W.Va., Belpre
Lake County Industrial Mutual Aid Organization (F)	Willoughby, Cleveland
Euclid Industrial Mutual Aid Association (F)	Euclid, Cleveland
Evendale Industrial Mutual Aid Association (F)	Cincinnati, Evendale, Sharonville
Reading Mutual Aid Association (F)	Cincinnati, Evendale, Lockland, Reading
Sandusky Mutual Aid Association	Sandusky, Cleveland
Sharonville Industrial Mutual Aid Council	Cincinnati, Newtown, Sharonville, St. Bernard
Toledo Mutual Aid Organization (F)	Toledo

Oklahoma	Tulsa Mutual Aid Association	Tulsa
	Oklahoma City Mutual Aid Association	Oklahoma City
Pennsylvania	Beaver County Industrial Defense Council	Aliquippa, Ambridge, Beaver, Freedom, Beaver Falls, Junction Park, Midland, Monaca
	New York-Pennsylvania Group of National Petroleum Association of Fire and Safety Marshals (F)	Bradford, Buffalo, N.Y., Farmers Valley, Warren
	Danville Mutual Aid Council	Danville
	Erie Mutual Aid	Erie
	Philadelphia Industrial Mutual Aid Organization (F)	Philadelphia
	National Petroleum Association and Fire & Accident Prevention Group (F)	Emlenton, Franklin, Freedom, Oil City, Petrolia, Rousseville
	Berks County Industrial Mutual Aid Organization	Reading, Laureldale
	Montgomery County Mutual Aid Association (F)	Conshohocken, Norristown, Plymouth Meeting
Tennessee	Kingsport Industrial Mutual Aid Organization	Kingsport
Texas	Houston Ship Channel Industries Disaster Aid Group (F)	Baytown, Channelview, Deer Park, Freeport, Galena Park, Houston, LaPorta, Miller Cut Off, Pasadena
	Fort Worth Mutual Aid Association	Ft. Worth, White Settlement
	Victoria-Calhoun Counties Mutual Aid Organization	Point Comfort, Seadrift, Victoria
	Corpus Christi Terminal Fire Company	Corpus Christi
	Sabine-Neches Fire Chiefs Association (F)	Beaumont, Groves, Nederland, Orange, Port Acres, Port Arthur, Port Neches, San Antonio

	Texas City Industrial Mutual Mutual Aid Association (F)	Texas City
Virginia	Central Virginia Industries Association	Lynchburg
West Virginia	Kanawha Valley Industrial Emergency Planning Council (KVIEPC) (F)	Alloy, Belle, Charleston, East Charleston, South Charleston, Corton, Dunbar, Institute, Longacre, Nitro
	Weirton Industrial Emergency Organization	Weirton
	Northern Ohio River Industrial Mutual Aid Council (NORIMAC)	Moundsville
Wisconsin	Milwaukee Industrial Mutual Aid Association	Milwaukee
	Cudahy Industrial Mutual Aid Association	Kenosha, Barrington, Ill.
	Elkhorn National Mobilization Program	Elkhorn

APPENDIX E

SAFETY AIDS

Safety aids presented in this section include descriptions and examples of MCA Chem-Cards, standard labels and placards, and chemical safety data sheets of three types.

E.1 MCA CHEM-CARDS

Exhibit E-1 lists the chemicals for which Chem-Cards are available as of November 1971. The list is periodically augmented as cards for additional chemicals are approved. Exhibits E-2 and E-3 are representative Chem-Cards. The entire compilation is available from the Manufacturing Chemists' Association, 1825 Connecticut Avenue, N. W., Washington, D. C., Zip Code 20009, for about $1.00 per manual. Representative Chem-Cards follow.

Contents

	Chemical	Chem-Card Number
A	Acetaldehyde	49
	Acetone	23
	Acetone Cyanhydrin	34
	Acetonitrile	64
	Acrolein (Inhibited)	76
	Acrylonitrile	15
	Aerozine 50	9
	Allyl Alcohol	35
	Allyl Chloride	63
	Ammonia, Anhydrous	44
	Ammonia, Aqua	66
	Ammonium Hydroxide	66
	Anhydrous Ammonia	44
	Anhydrous Hydrazine	7
	Aniline Oil (Liquid)	51
B	Benzene	17
	Benzol	17
	Benzyl Chloride	54
	Bromine	59
	Bromomethane	38
	Butadiene (Inhibited)	81
	Butanol	80
	Butyl Acetate	60
	Butyl Alcohol (Secondary or Tertiary)	80
	Butyllithium	28
	Butyraldehyde	50
C	Carbolic Acid	48
	Caustic Potash (Liquid)	32
	Caustic Soda (Liquid)	33
	Chlorine	53
	Chlorine Trifluoride	2
	Chlorosulfonic Acid	73
	Cresol	77
	Cresylic Acid	77
C	CTF	2
	Cyclohexane	20
D	Diethylamine (Anhydrous)	27
	Diethylenetriamine	72
	Dimethylamine (Anhydrous)	26
	Dimethylamine (Aqueous)	84
	Dimethyl Ether	61
	Dimethyl Sulfate	55
E	Epichlorohydrin	29
	Ethanol	70
	Ether	16
	Ethyl Acetate	18
	Ethyl Acrylate	85
	Ethyl Alcohol	70
	Ethyl Aldehyde	49
	Ethyl Chloride	24
	Ethylene Dichloride	62
	Ethylene Oxide	36
	Ethyl Ether	16
F	Fluorine, Liquid	10
	Formic Acid	83
	Fuming Sulfuric Acid (Oleum)	68
H	Hydrazine, Anhydrous	7
	Hydrazine/UDMH	9
	Hydrochloric Acid	82
	Hydrofluoric Acid (Anhydrous or Aqueous)	42
	Hydrogen, Liquid	12
	Hydrogen Peroxide (High Strength)	14
I	IRFNA	3
	Isopropanol	71
	Isopropyl Alcohol	71
	Isopropylamine	56
	Isopropyl Ether	58

Exhibit E-1. List of Available Chem-Cards

Contents

Chemical — **Chem-Card Number**

L
Liquid Fluorine 10
Liquid Hydrogen 12
Liquid Nitrogen 6
Liquid Oxygen 13

M
Methanol 69
Methyl Acrylate 74
Methyl Alcohol 69
Methylamines (Anhydrous) 26
Methylamines (Aqueous) 84
Methyl Bromide (Liquid) 38
Methyl Chloride 67
Methyl Ethyl Ketone 22
Methyl Isobutyl Ketone 57
Methyl Methacrylate 43
Mixed Acid 65
Monomethylamine (Anhydrous) 26
Monomethylamine (Aqueous) 84
Monomethyl Hydrazine 11
Motor Fuel Antiknock Compound 30
Muriatic Acid 82

N
Nitrating Acid 65
Nitric Acid 47
Nitric Acid, Red Fuming 3
Nitrobenzene 79
Nitrobenzol (Liquid) 79
Nitrogen, Liquid 6
Nitrogen Tetroxide 1
N-Two-O-Four 1

O
Oil of Vitriol 25
Oleum 68
Oxygen, Liquid 13

P
Pentaborane 5
Perchloryl Fluoride 4

Chemical — **Chem-Card Number**

P
PF 4
Phenol 48
Phosphorus Oxychloride 39
Phosphorus Pentasulfide 41
Phosphorus Trichloride 40
Phosphorus, White or Yellow, in Water 37
Potassium Hydroxide 32

R
Red Fuming Nitric Acid 3
RFNA 3

S
Sodium Hydroxide 33
S-O-Two 78
Sodium (Metallic) 31
Sulfur Dioxide 78
Sulfuric Acid 25
Sulfur Trioxide (Stabilized) 52

T
Tetraethyl Lead, Liquid 30
Toluene 19
Toluol 19
Trimethylamine (Anhydrous) 26
Trimethylamine (Aqueous) 84

U
UDMH 8
Unsymmetrical Dimethyl Hydrazine 8

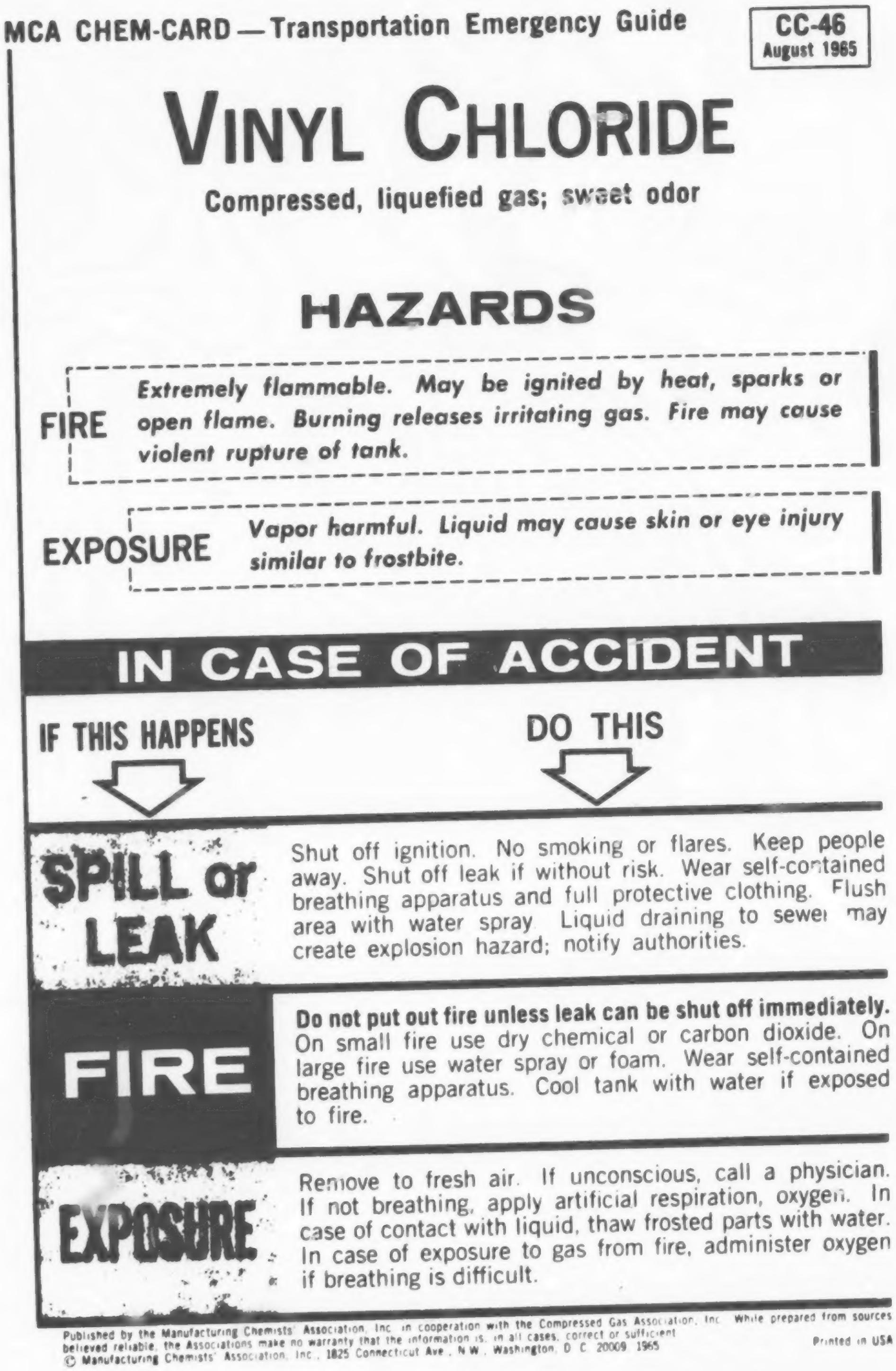
V
Vinyl Acetate 21
Vinyl Chloride 46
Vinylidene Chloride (Inhibited) 75

W
White Phosphorus, in Water 37

X
Xylene 45
Xylol 45

Y
Yellow Phosphorus, in Wate 37

Exhibit E-1. List of Available Chem-Cards (cont.)



MCA CHEM-CARD — Transportation Emergency Guide

CC-46
August 1965

VINYL CHLORIDE

Compressed, liquefied gas; sweet odor

HAZARDS

FIRE *Extremely flammable. May be ignited by heat, sparks or open flame. Burning releases irritating gas. Fire may cause violent rupture of tank.*

EXPOSURE *Vapor harmful. Liquid may cause skin or eye injury similar to frostbite.*

IN CASE OF ACCIDENT

IF THIS HAPPENS	DO THIS
SPILL or LEAK	Shut off ignition. No smoking or flares. Keep people away. Shut off leak if without risk. Wear self-contained breathing apparatus and full protective clothing. Flush area with water spray Liquid draining to sewer may create explosion hazard; notify authorities.
FIRE	**Do not put out fire unless leak can be shut off immediately.** On small fire use dry chemical or carbon dioxide. On large fire use water spray or foam. Wear self-contained breathing apparatus. Cool tank with water if exposed to fire.
EXPOSURE	Remove to fresh air. If unconscious, call a physician. If not breathing, apply artificial respiration, oxygen. In case of contact with liquid, thaw frosted parts with water. In case of exposure to gas from fire, administer oxygen if breathing is difficult.

Published by the Manufacturing Chemists' Association, Inc in cooperation with the Compressed Gas Association, Inc While prepared from sources believed reliable, the Associations make no warranty that the information is, in all cases, correct or sufficient
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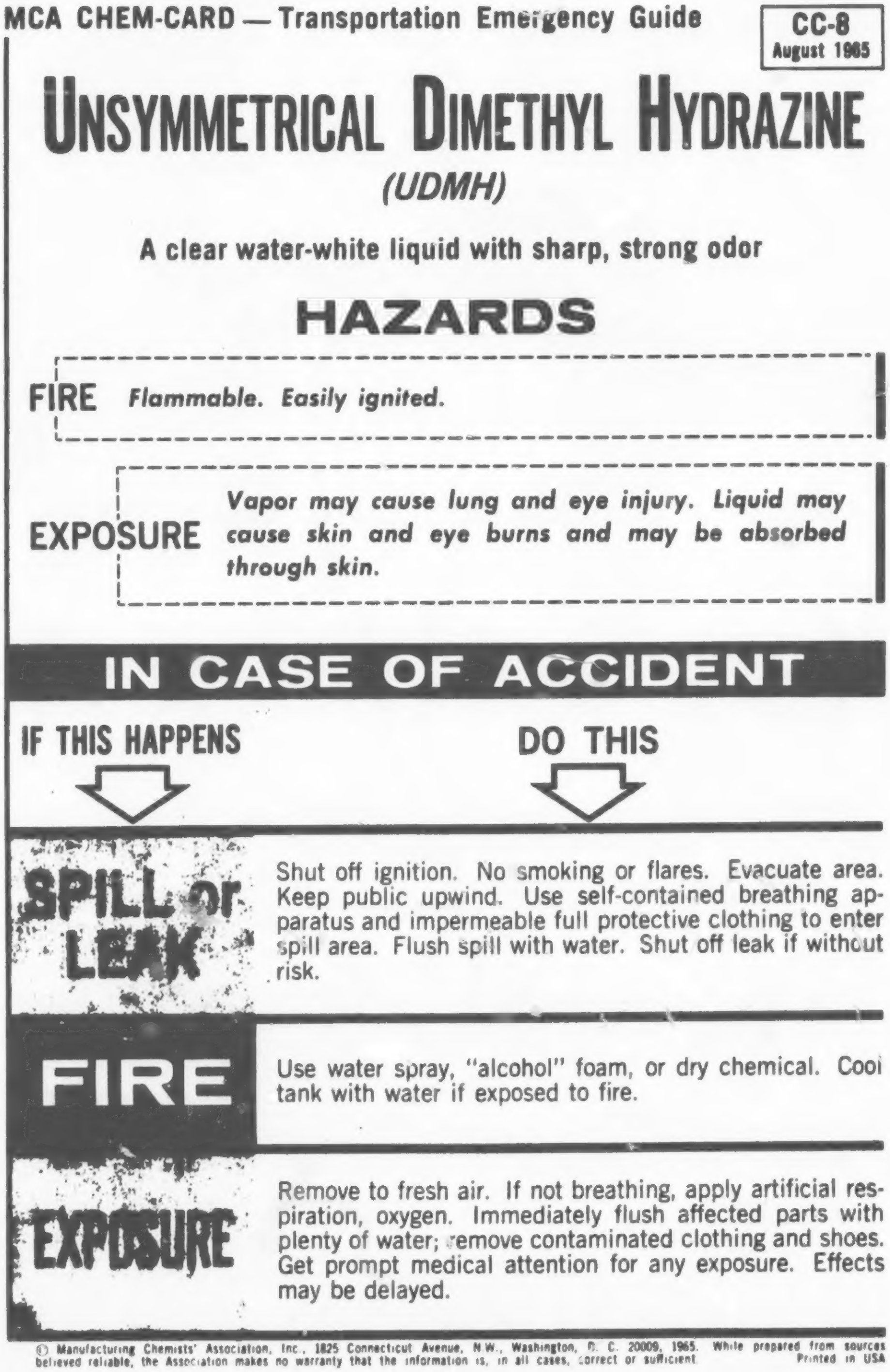
Printed in USA

Exhibit E-2. Sample MCA Chem-Card



MCA CHEM-CARD — Transportation Emergency Guide

CC-8
August 1965

UNSYMMETRICAL DIMETHYL HYDRAZINE

(UDMH)

A clear water-white liquid with sharp, strong odor

HAZARDS

FIRE *Flammable. Easily ignited.*

EXPOSURE *Vapor may cause lung and eye injury. Liquid may cause skin and eye burns and may be absorbed through skin.*

IN CASE OF ACCIDENT

IF THIS HAPPENS	DO THIS
SPILL or LEAK	Shut off ignition. No smoking or flares. Evacuate area. Keep public upwind. Use self-contained breathing apparatus and impermeable full protective clothing to enter spill area. Flush spill with water. Shut off leak if without risk.
FIRE	Use water spray, "alcohol" foam, or dry chemical. Cool tank with water if exposed to fire.
EXPOSURE	Remove to fresh air. If not breathing, apply artificial respiration, oxygen. Immediately flush affected parts with plenty of water; remove contaminated clothing and shoes. Get prompt medical attention for any exposure. Effects may be delayed.

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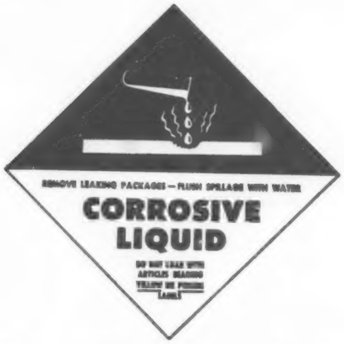
Exhibit E-3. Sample MCA Chem-Card

E.2 LABELS AND PLACARDS

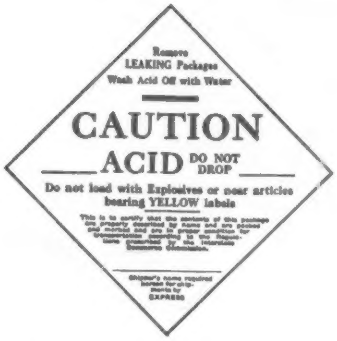
Examples of identifying placards and labels that are posted on the exterior of carriers hauling hazardous material were shown in Figure on page 7-21. The following, Exhibit E-4, is a more complete set furnished by the Railway Systems and Management Association. It appears in the RSMA "Manual, Commodity Safety System," which is part of the Chemical Transportation Safety Index slide rule set (see page 5-16).

WHITE (Air)


REMOVE LEAKING PACKAGES — FLUSH SPILLAGE WITH WATER
CORROSIVE
LIQUID

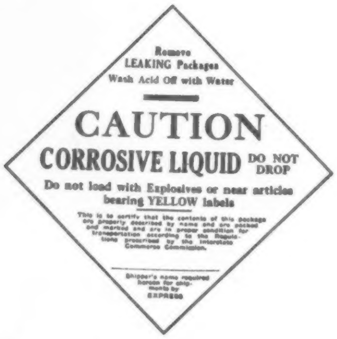
Required on packages containing acids, alkaline caustic liquids and other corrosive liquids for air shipment.

WHITE


Remove
LEAKING Packages
Wash Acid Off with Water
CAUTION
ACID
DO NOT DROP
Do not load with Explosives or near articles bearing YELLOW labels

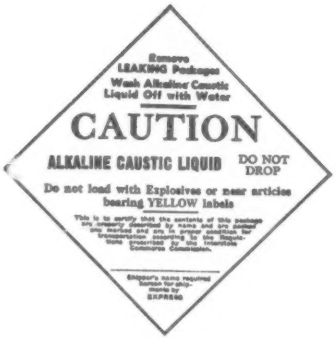
Required on packages containing acids for rail, truck or water shipment.

WHITE


Remove
LEAKING Packages
Wash Acid Off with Water
CAUTION
CORROSIVE LIQUID
DO NOT DROP
Do not load with Explosives or near articles bearing YELLOW labels

Required on packages containing corrosive liquids for rail, truck or water shipment.

WHITE


Remove
LEAKING Packages
Wash Alkaline Caustic Liquid Off with Water
CAUTION
ALKALINE CAUSTIC LIQUID
DO NOT DROP
Do not load with Explosives or near articles bearing YELLOW labels

Required on packages containing alkaline caustic liquids for rail, truck or water shipment.

Exhibit E-4. Hazardous Materials Labels and Placards

DOME PLACARD

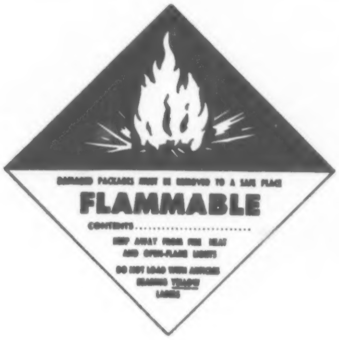
AVOID ACCIDENTS

DO NOT REMOVE THIS DOME COVER
WHILE GAS PRESSURE EXISTS IN TANK

KEEP LIGHTED LANTERNS AWAY

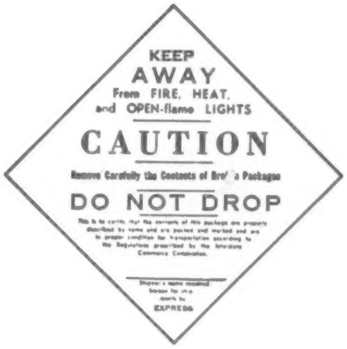
Required on tank car domes when the tank car contains flammable liquids that build up relatively high pressures inside the tank (vapor pressures greater than 16 and less than 40 psi absolute at 100°F).

YELLOW (Air) *


DAMAGED PACKAGES MUST BE REMOVED TO A SAFE PLACE
FLAMMABLE
CONTENTS
KEEP AWAY FROM FIRE HEAT
AND OPEN-FLAME LIGHTS
DO NOT LOAD WITH ARTICLES
BEARING YELLOW
LABELS

Required on packages containing flammable solids or oxidizing materials for air shipments.*

YELLOW *


KEEP
AWAY
From FIRE, HEAT,
and OPEN-flame LIGHTS
CAUTION
Remove Carefully the Contents of Bro' a Packages
DO NOT DROP
EXPRESS

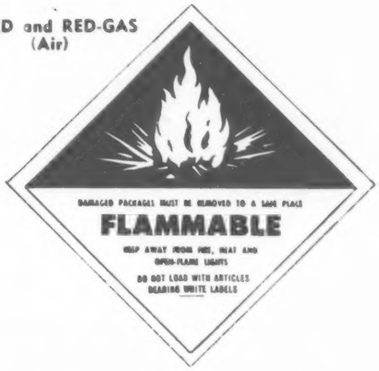
Required on packages containing flammable solids or oxidizing materials for rail, truck or water shipment.*

---

* CAUTION: Although the labels are the same, the hazards of flammable solids differ from those of oxidizing materials, and the risk is increased if one is near the other. Check container or waybill to determine exact contents, then consult Safety Index for proper handling instructions.

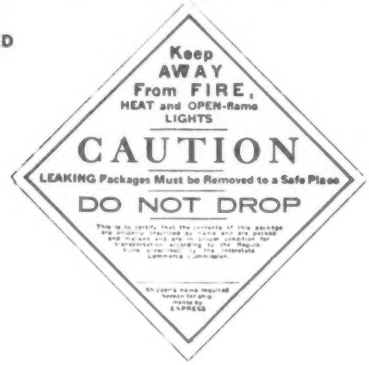
Exhibit E-4. Hazardous Materials Labels and Placards (cont.)

RED and RED-GAS
(Air)


DAMAGED PACKAGES MUST BE REMOVED TO A SAFE PLACE
FLAMMABLE
KEEP AWAY FROM FIRE, HEAT AND
OPEN-FLAME LIGHTS
DO NOT LOAD WITH ARTICLES
BEARING WHITE LABELS

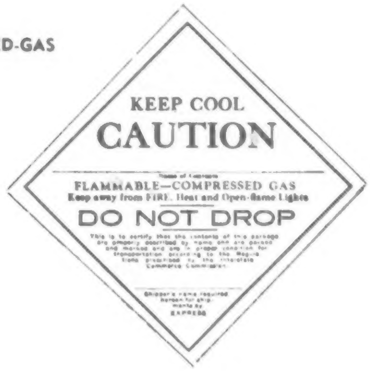
Required on packages containing flammable liquids or gases for air shipment

RED


Keep
AWAY
From FIRE,
HEAT and OPEN-flame
LIGHTS
CAUTION
LEAKING Packages Must be Removed to a Safe Place
DO NOT DROP

Required on packages containing flammable liquids for rail, truck or water shipment

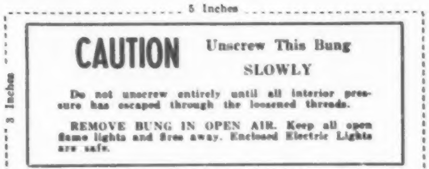
RED-GAS


KEEP COOL
CAUTION
FLAMMABLE—COMPRESSED GAS
Keep away from FIRE, Heat and Open-flame Lights
DO NOT DROP

Required on packages containing flammable gases for rail, truck and water shipment

Exhibit E-4. Hazardous Materials Labels and Placards (cont.)

BUNG LABEL


5 Inches

3 Inches

CAUTION

Unscrew This Bung

SLOWLY

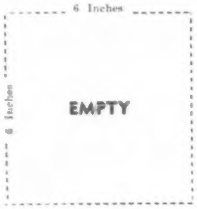
Do not unscrew entirely until all interior pressure has escaped through the loosened threads.

REMOVE BUNG IN OPEN AIR. Keep all open flame lights and fires away. Enclosed Electric Lights are safe.

Required near the bung on metal drums or barrels containing flammable liquids that build up relatively high pressures when contained (specifically with vapor pressures greater than 16 and less than 40 psi absolute at 100°F). This label is in addition to the red label required for flammable liquids.

EMPTY

Required on emptied containers upon which the old label has not been removed, obliterated or destroyed; it should cover the old label.


6 Inches

6 Inches

EMPTY

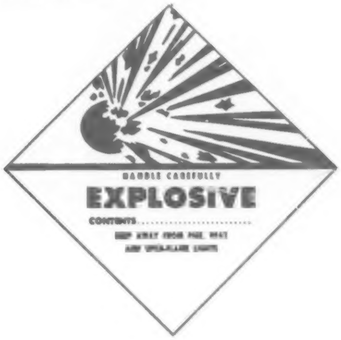
EXPLOSIVES—DESCRIPTION OF CLASSES

Class A explosives are detonating or other types of maximum hazard, and do not have a specific label. Packages containing Class A explosives have specific markings as required in D.O.T. regulations, such as "HIGH EXPLOSIVES—DANGEROUS," "DETONATING PRIMERS—HANDLE CAREFULLY," etc.

Class B explosives are flammable hazard types of explosives which, generally, combust rapidly, rather than detonate.

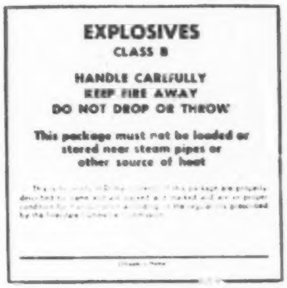
Class C explosives are of minimum hazard and generally are those containing small amounts of Class A or B explosives, and some types of fireworks. Class C explosives, other than special fireworks, require no label, but may require specific markings as specified in D.O.T. regulations.

EXPLOSIVES (Air)



Required on packages containing Class B explosives, Class C explosives, special fireworks or samples of explosives for air shipment.

EXPLOSIVES—B


EXPLOSIVES

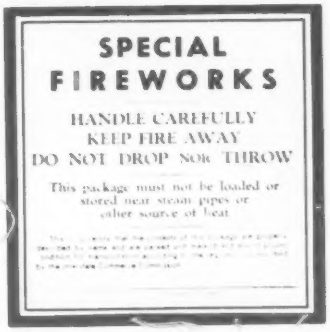
CLASS B

HANDLE CAREFULLY
KEEP FIRE AWAY
DO NOT DROP OR THROW

This package must not be loaded or stored near steam pipes or other source of heat

Required on packages containing Class B explosives for rail, truck or water shipment

SPECIAL FIREWORKS

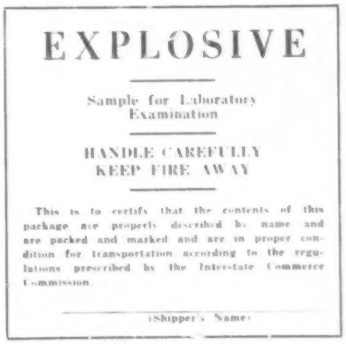

SPECIAL FIREWORKS

HANDLE CAREFULLY
KEEP FIRE AWAY
DO NOT DROP NOR THROW

This package must not be loaded or stored near steam pipes or other source of heat

Required on packages containing special fireworks for rail, truck or water shipment

EXPLOSIVES-SAMPLE


EXPLOSIVE

Sample for Laboratory Examination

HANDLE CAREFULLY
KEEP FIRE AWAY

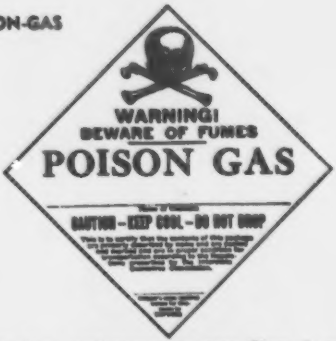
This is to certify that the contents of this package are properly described by name and are packed and marked and are in proper condition for transportation according to the regulations prescribed by the Interstate Commerce Commission.

(Shipper's Name)

Required on packages containing samples of explosives for laboratory examination for rail, truck or water shipment

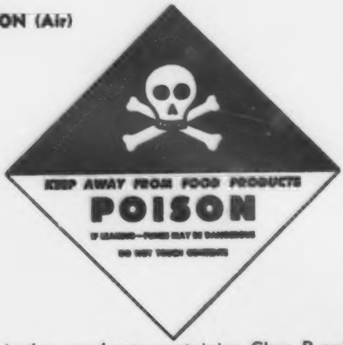
Exhibit E-4. Hazardous Materials Labels and Placards (cont.)

POISON-GAS


WARNING!
BEWARE OF FUMES
POISON GAS
CAUTION—KEEP COOL—DO NOT DROP

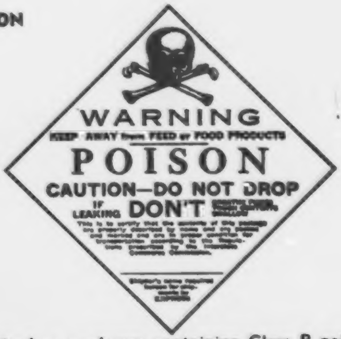
Required on packages containing Class A poison gases or liquids (a small amount of the gas or vapor of the liquid is dangerous to life) for shipment on any mode. A Class A poison that is also a flammable (gas, liquid or solid), corrosive liquid, oxidizing material or compressed gas must bear the additional label showing the other hazardous characteristic.

POISON (Air)


KEEP AWAY FROM FOOD PRODUCTS
POISON
DO NOT TOUCH CONTENTS

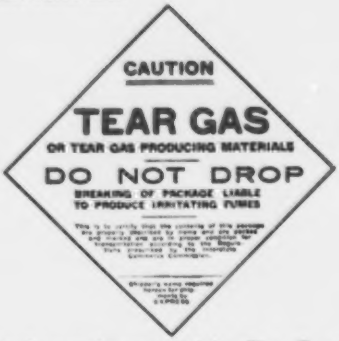
Required on packages containing Class B poisons (liquid or solid poisons, less dangerous than Class A) or Class C poisons (tear gas or irritating substances) for air shipment.

POISON


WARNING
KEEP AWAY from FEED or FOOD PRODUCTS
POISON
CAUTION—DO NOT DROP
IF LEAKING DON'T

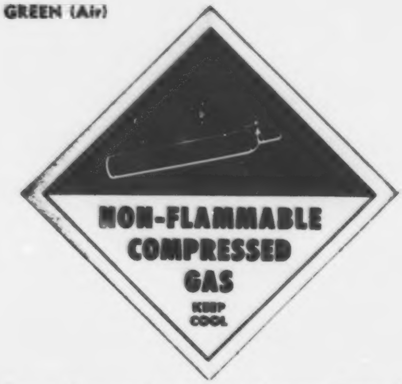
Required on packages containing Class B poisons for rail, truck or water shipment.

POISON-TEAR GAS


CAUTION
TEAR GAS
OR TEAR GAS PRODUCING MATERIALS
DO NOT DROP
BREAKING OF PACKAGE LIABLE TO PRODUCE IRRITATING FUMES

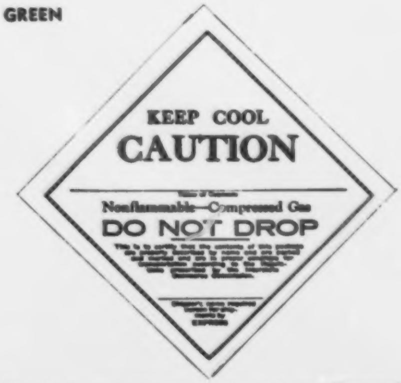
Required on packages containing Class C poisons for rail, truck or water shipment.

GREEN (Air)


NON-FLAMMABLE
COMPRESSED
GAS
KEEP
COOL

Required on packages containing non-flammable gases for air shipment.

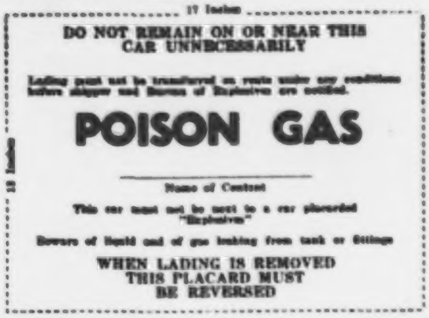
GREEN


KEEP COOL
CAUTION
Nonflammable—Compressed Gas
DO NOT DROP

Required on packages containing non-flammable gases for rail, truck or water shipment.

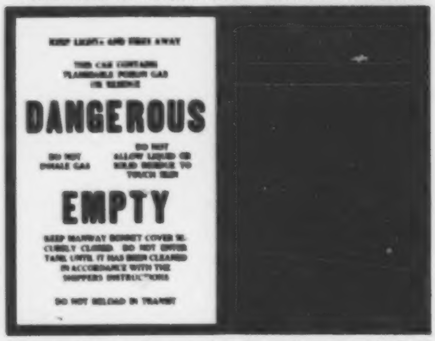
Exhibit E-4. Hazardous Materials Labels and Placards (cont.)

POISON GAS PLACARD


17 Inches
13 Inches
DO NOT REMAIN ON OR NEAR THIS CAR UNNECESSARILY
POISON GAS
Name of Content
WHEN LADING IS REMOVED THIS PLACARD MUST BE REVERSED

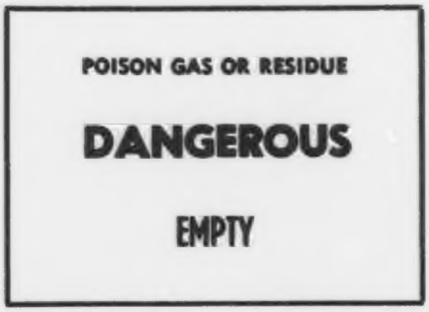
Required on tank cars containing Class A poison gases, except hydrocyanic acid.

"FLAMMABLE POISON GAS—EMPTY" PLACARD


DANGEROUS
EMPTY
DO NOT RELOAD IN TRANSIT

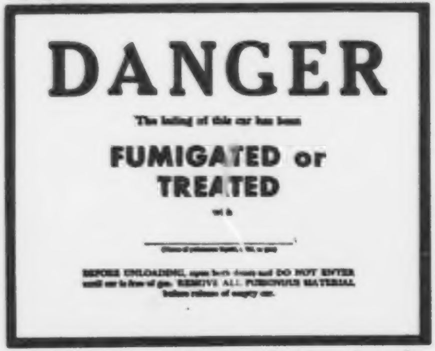
Required on tank cars that have been emptied of hydrocyanic acid.

"POISON GAS—EMPTY" PLACARD


POISON GAS OR RESIDUE
DANGEROUS
EMPTY

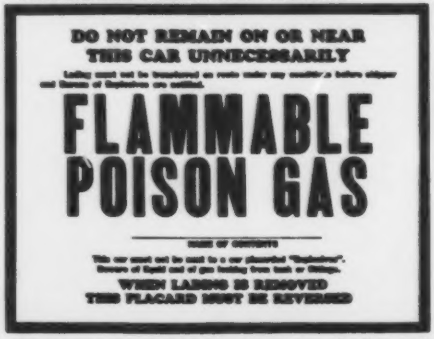
Required on tank cars that have been emptied of Class A poison gasses, except hydrocyanic acid.

"DANGER—FUMIGATED OR TREATED" PLACARD


DANGER
The lading of this car has been
FUMIGATED or TREATED

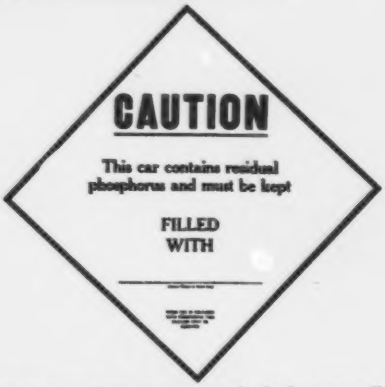
Required on cars with ladings that have been fumigated or treated with a poisonous solid, liquid or gas.

FLAMMABLE POISON GAS PLACARD


DO NOT REMAIN ON OR NEAR THIS CAR UNNECESSARILY
FLAMMABLE POISON GAS
WHEN LADING IS REMOVED THIS PLACARD MUST BE REVERSED

Required on tank cars containing hydrocyanic acid, a highly flammable Class A poison gas.

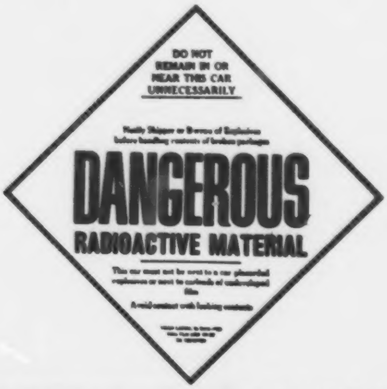
RESIDUAL PHOSPHORUS PLACARD


CAUTION
This car contains residual phosphorus and must be kept
FILLED WITH

Required on tank cars emptied of white or yellow phosphorous and being shipped back filled with water or inert gas.

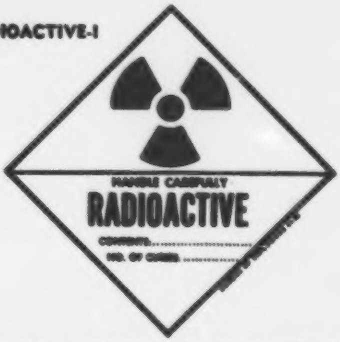
Exhibit E-4. Hazardous Materials Labels and Placards (cont.)

DANGEROUS RADIOACTIVE MATERIAL PLACARD


DO NOT
REMAIN IN OR
NEAR THIS CAR
UNNECESSARILY
DANGEROUS
RADIOACTIVE MATERIAL

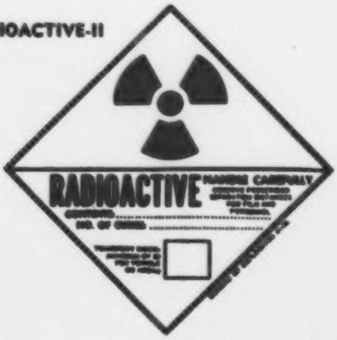
Required on cars containing packages with Radioactive-III labels, on carload lots of low specific activity materials, carload lots above certain radiation levels and carload lots of radioactive materials loaded by a shipper in containers assigned for his sole use.

RADIOACTIVE-I


HANDLE CAREFULLY
RADIOACTIVE
CONTENTS
NO. OF CURIES

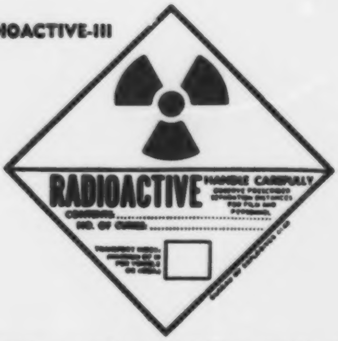
Required on packages containing certain classes of radioactive materials for shipment on any mode.*

RADIOACTIVE-II


RADIOACTIVE
HANDLE CAREFULLY
CONTENTS
NO. OF CURIES

Required on packages containing certain classes of radioactive materials for shipment on any mode.*

RADIOACTIVE-III


RADIOACTIVE
HANDLE CAREFULLY
CONTENTS
NO. OF CURIES

Required on packages containing certain classes of radioactive materials for shipment on any mode.*

---

*The numbers I, II and III on the labels above connote progressively higher radiation hazards. A radioactive material that is also a flammable (gas, liquid or solid), corrosive liquid, Class B poison, oxidizing material or compressed gas must bear the additional label showing the other hazardous characteristic.

Exhibit E-4. Hazardous Materials Labels and Placards (cont.)

E.3 SAFETY DATA SHEETS

Chemical safety data sheets are copyrighted information summaries on individual hazardous chemicals. They vary in size and content from the comprehensive multi-page discussions of the Manufacturing Chemists' Association (MCA) to the two-page highlights of the Railway Systems and Management Association (RSMA). This section presents samples of each type, along with intermediate-sized safety data sheets published by the National Safety Council (NSC). Information on obtaining these publications follows.

Safety data sheets published by still another organization, the American Industrial Hygiene Association (AIHA), are not shown here. Entitled "AIHA Hygienic Guides," these data sheets summarize toxicological data for establishing relative health hazard and recommend control measures to minimize exposure. They may be obtained from the American Industrial Hygiene Association, 14125 Prevost Street, Detroit, Michigan 48227.

E.3.1 MCA Chemical Safety Data Sheets

MCA safety data sheets provide detailed information on the physical properties and safe storage, handling, transportation, use, and disposal of hazardous chemicals. Exhibit E-5 presents a list of available MCA Chemical Safety Data Sheets and the address where they may be obtained. They are priced at $0.50 per sheet (November 1971). Exhibit E-6 is the MCA safety data sheet for Ethylene Oxide.

For free Publications list and prices, write or phone
Publications Department
MANUFACTURING CHEMISTS ASSOCIATION
1825 Connecticut Avenue, Washington, D. C. 20009
Phone: 202–483-6126

OTHER CHEMICAL SAFETY DATA SHEETS AVAILABLE IN THIS AREA

(Date of latest available edition, as of July 1969, given in parentheses)

Acetaldehyde	(1952)	SD-43
Acetic Acid	(1951)	SD-41
Acetic Anhydride	(1962)	SD-15
Acetone	(1962)	SD-87
Acetylene	(1957)	SD-7
Acrolein	(1961)	SD-85
Acrylonitrile	(1964)	SD-31
Aluminum Chloride	(1956)	SD-62
Ammonia Anhydrous	(1960)	SD-8
Ammonia Aqua	(1947)	SD-13
Ammonium Dichromate	(1952)	SD-45
Aniline	(1963)	SD-17
Antimony Trichloride (Anhydrous)	(1957)	SD-66
Arsenic Trioxide	(1956)	SD-60
Benzene	(1960)	SD-2
Benzoyl Peroxide	(1960)	SD-81
Benzyl Chloride	(1957)	SD-69
Betanaphthylamine	(1949)	SD-32
Boron Hydrides	(1961)	SD-84
Bromine	(1968)	SD-49
Butadiene	(1954)	SD-55
n-Butyllithium in Hydrocarbon Solvents	(1966)	SD-91
Butyraldehydes	(1960)	SD-78
Calcium Carbide	(1967)	SD-23
Carbon Disulfide	(1967)	SD-12
Carbon Tetrachloride	(1963)	SD-3
Caustic Potash	(1968)	SD-10
Caustic Soda	(1968)	SD-9
Chlorine	(1960)	SD-80
Chloroform	(1962)	SD-89
Chlorosulfonic Acid	(1968)	SD-33
Chromic Acid	(1952)	SD-44
Cresol	(1952)	SD-48
Cyclohexane	(1957)	SD-68
Diethylenetriamine	(1959)	SD-76
Dimethyl Sulfate	(1966)	SD-19
Dinitrotoluenes	(1966)	SD-93
Ethyl Acetate	(1953)	SD-51
Ethyl Chloride	(1953)	SD-50
Ethyl Ether	(1965)	SD-29
Ethylene Dichloride	(1947)	SD-18
Ethylene Oxide	(1951)	SD-38
Formaldehyde	(1960)	SD-1
Hydrochloric Acid	(1951)	SD-39
Hydrocyanic Acid	(1961)	SD-67
Hydrofluoric Acid	(1957)	SD-25
Hydrogen Peroxide	(1969)	SD-53
Hydrogen Sulfide	(1968)	SD-36
Isopropylamine	(1959)	SD-72
Lead Oxides	(1956)	SD-64
Maleic Anhydride	(1962)	SD-88
Methanol	(1948)	SD-22
Methyl Acrylate and Ethyl Acrylate	(1960)	SD-79
Methylamines	(1955)	SD-57
Methyl Bromide	(1968)	SD-35
Methyl Chloride	(1951)	SD-40
Methylene Chloride	(1962)	SD-86
Methyl Ethyl Ketone	(1961)	SD-83
Mixed Acid	(1956)	SD-65
Naphthalene	(1956)	SD-58
Nitric Acid	(1961)	SD-5
paraNitroaniline	(1966)	SD-94
Nitrobenzene	(1967)	SD-21
Ortho-Dichlorobenzene	(1953)	SD-54
Paraformaldehyde	(1960)	SD-6
Perchloroethylene	(1948)	SD-24
Perchloric Acid Solution	(1965)	SD-11
Phenol	(1964)	SD-4
Phosgene	(1967)	SD-95
Phosphoric Acid	(1958)	SD-70
Phosphoric Anhydride	(1948)	SD-28
Phosphorus, Elemental	(1947)	SD-16
Phosphorus Oxychloride	(1968)	SD-26
Phosphorus Pentasulfide	(1958)	SD-71
Phosphorus Trichloride	(1948)	SD-27
Phthalic Anhydride	(1956)	SD-61
Propylene	(1956)	SD-59
Sodium Chlorate	(1952)	SD-42
Sodium Cyanide	(1967)	SD-30
Sodium, Metallic	(1952)	SD-47
Sodium and Potassium Dichromates	(1952)	SD-46
Styrene Monomer	(1951)	SD-37
Sulfur	(1959)	SD-74
Sulfur Chlorides	(1960)	SD-77
Sulfur Dioxide	(1953)	SD-52
Sulfuric Acid	(1963)	SD-20
Tetrachloroethane	(1949)	SD-34
Toluene	(1956)	SD-63
Toluidine	(1961)	SD-82
Tolylene Diisocyanate	(1959)	SD-73
1, 1, 1-Trichloroethane	(1965)	SD-90
Trichloroethylene	(1956)	SD-14
Vinyl Acetate	(1959)	SD-75
Vinyl Chloride	(1954)	SD-56
Zirconium and Hafnium Powder	(1966)	SD-92

Exhibit E-5. MCA List of Safety Data Sheets

CHEMICAL SAFETY DATA SHEET

ETHYLENE OXIDE

SUMMARY

Ethylene oxide is a chemical widely used both in the chemical industry and research laboratories. Its use involves a variety of hazards. These are clearly set forth in this Chemical Safety Data Sheet. Requisite precautions are outlined with regard to its flammable vapors and explosion hazards arising from its variable physical state, as well as when the chemical is subjected to polymerization conditions, particularly when in contact with certain catalytic influences. Likewise the common hazards involved in handling; loading and unloading of tank cars and drums; storage conditions, and buildings, including waste disposal, are placed in proper safety perspective with respect to pertinent safeguards.

Utmost care and diligence have been exercised in pointing out the hazards that might occur if adequate protection and safety precautions are not followed. In view of the extreme care necessary to protect handlers, considerable space has been devoted to the proper choice of protective equipment, suitable clothing, eye protection, masks, etc.

It is important that the suggestions given for first aid in case of exposure be followed. No cases of chronic poisoning by ethylene oxide have been reported, but exposure to excessive concentrations may result in distressing acute effects, including skin burns, injury to the eyes, and irritation of the mucous membranes of the nose and throat. Nausea and vomiting also may occur.

To avoid all dangers and hazards, particular stress is placed on thorough education of employees. In order to appreciate fully the respective danger signals it is urgent that each part and specific section of the Safety Data Sheet on ethylene oxide be carefully examined.

Exhibit E-6. MCA Chemical Safety Data Sheet on Ethylene Oxide

Manual
Sheet
SD-38

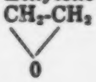
Chemical Safety Data Sheet

ETHYLENE OXIDE

Adopted February, 1951

1. NAME

Chemical Names:	Ethylene oxide, 1,2-epoxyethane; oxirane; dimethylene oxide
Common Names:	Ethylene oxide
Formula:	CH_2-CH_2


$$\underset{O}{CH_2\text{-}CH_2}$$

2. PROPERTIES

2.1 Grades and Strength

Commercial, substantially 100%.

2.2 Important Physical and Chemical Properties.

	Liquid	*Gas*
Boiling Point (760 mm):	10.73° C (51.3° F)	—
Coefficient of Expansion,		
20° C (68° F):	0.00161 per °C	—
55° C (130° F):	0.00170 per °C	—
73.9° C (165° F):	0.00205 per °C	—
Color:	Colorless	Colorless
Corrosivity:	Noncorrosive	Noncorrosive
Critical Pressure; lb./sq. in. abs.:	—	1043
Critical Temperature:	—	195.8° C (384.4° F)
Explosive Limits: See 2.3.3; 6.2.2 and 8.3.2(d)	Non-explosive	Explosive
Per cent by volume in air;		
Upper Limit:	—	100 } See 8.3.2(d)
Lower Limit:	—	3 }
Flash Point; Liquid Ignition Temp. (decomposition)		
Tag Glass Open Cup:	<0.° F	—
Heat of Combustion; Kgm.cal./gm mol:	—	308.7
Heat of Decomposition; Kgm.cal./gm mol:	—	20.0
Heat of Vaporization; 1 atm., BTU/lb.:	245	—
Hygroscopicity	Slight	—
Ignition Temperature; In air, 1 atm.:	—	429° C (804.2° F)
Ignition Temperature, (Auto-ignition); 1 atm.:	—	571° C (1060.8° F)
Melting Point:	—111.3°C (—168.3°F)	—

Odor:	Characteristic ether-like odor, but irritating in high concentration.	Characteristic ether-like odor, but irritating in high concentration.
Reactivity, Chemical:	Dangerously reactive; some reactions uncontrolled.	Dangerously reactive; some reactions uncontrolled.
Specific Gravity, apparent; 20/20° (68° F):	0.8711	—
Specific Heat:	0.44 BTU/lb. per degree F	0.268 Cal/gram per °C (1 atm. 34° C)
Solubility in Water:	Complete	—
Vapor Density, Air—1 at 40° C (104° F):	—	1.49
Vapor Pressure; 20° C, lb./sq. in. abs.:	—	21.2 (see following table)
Volatility	Very volatile	

Vapor Pressure

Temperature		Vapor Pressure of Ethylene Oxide		
°C	°F	mm Mercury abs.	Inches mercury abs.	Psig abs.
—57.0	—70.6	19.5	0.76	—
—30.4	—22.7	110.6	4.35	—
—10.5	—14.9	312.7	12.31	—
0.0	32.0	493.1	19.41	—
10.73	51.3	760.0	29.92	14.7
20.0	68.0	1095.0	43.11	21.2
30.0	86.0	1560.0	61.42	30.0
69.8	157.6	5141.0	202.4	96.5
109.8	229.6	12,720.0	500.8	245.0

2.3 Hazardous Properties

2.3.1 *HEALTH HAZARDS*

Ethylene oxide vaporizes rapidly at atmospheric temperatures and pressures. Its vapor is moderately toxic by inhalation, and is irritating to the eyes and mucous membranes. Ethylene oxide as pure liquid, or in solution, can produce burns of the skin and eyes. (See 8. HEALTH HAZARDS AND THEIR CONTROL.)

2.3.2 *FIRE HAZARDS*

Ethylene oxide is an extremely flammable liquid and, as such, introduces a potential fire hazard when it is stored, handled or used. Ethylene oxide fires will continue to burn until the liquid is diluted with approximately 22 volumes of water to one volume of oxide. Most small fires may be extinguished with carbon dioxide or dry chemical agents, if properly applied. (See 6.2.1 Fire Hazards.)

2.3.3. *EXPLOSION HAZARDS*

Liquid ethylene oxide itself is quite stable to detonating agents, but the vapor will explode when exposed to an electric spark, static electricity, excess heat, an open flame, decomposing acetylides, or detonating agents. Vapor and air mixtures are more explosive than the vapor alone and must be handled accordingly. In a confined space the explosion pressure developed may be in the range of 16 to 50 (plus) times the initial pressure depending on the initial pressure and the volume-to-surface ratio of the container. As the volume-to-surface ratio of the container is increased pressures might be developed in excess of 50 times the initial pressure. Explosions from internal sources may be prevented by proper dilution with an inert gas such as nitrogen. Ignition from outside sources should be guarded against by adequate insulation and water spray systems. (See 6.2.2 Explosion Hazards.)

2.3.4 *POLYMERIZATION HAZARDS*

Ethylene oxide may rearrange chemically and/or polymerize violently when in contact with highly active catalytic surfaces such as anhydrous iron, tin, and aluminum chlorides; pure iron and aluminum oxides; and alkali metal hydroxides. (See 6.2.3 Polymerization Hazards.)

Ethylene oxide may also react with other materials and thus create enough heat to accelerate polymerization of unreacted oxide (See 5.2.3).

3. USUAL SHIPPING CONTAINERS

3.1 Type and Size

Cylinders, steel; one pound capacity; ICC-3B300

Cylinders, steel; one-gallon capacity; ICC-4B400

Lagged steel drums; not over 61 gallon capacity; ICC-5P (maximum filling capacity for 61 gallon drum must not exceed 55 gallons of ethylene oxide at 60° F).

Tank Car, insulated; ICC 104A; 104A-W, or ARA-IVA.

3.2 Label or Identification

3.2.1 The Manufacturing Chemists' Association recommends the following label in addition to, or in combination with, any label warning required by statutes, regulations, or ordinances:

3.2.2 ICC Regulations require the ICC red label for flammable liquids.

3.2.3 Tank cars and railroad cars carrying one or more containers of ethylene oxide must bear the ICC "DANGEROUS" placard.

3.3 Disposal and Return Precautions

3.3.1 Small containers (ICC-3B300 and ICC-4B400) should be drained free of liquid ethylene oxide and the valves closed tightly before they are returned to the supplier. No air should be permitted to enter the container.

3.3.2 Insulated Drums and Tank Cars: When all of the liquid ethylene oxide has been removed from the insulated drum or car, the valves should be closed and the valve plugs replaced. No air should be permitted to enter the vessel. The inert gas used for the unloading procedures (See 4. UNLOADING AND EMPTYING) should be left in the drum or tank car at a pressure not in excess of 35 psig at 70° F. A pressure of 35 psig is felt advisable because the resulting partial pressure of ethylene oxide will be low enough to be outside the detonable range. A residual pressure of 35 psig is definitely indicated as a safety measure.

3.3.3 Ethylene oxide containers should not be used for any other product.

3.3.4 As soon as a tank car is completely unloaded, all valves must be made tight, the unloading connections must be removed and all

ETHYLENE OXIDE

DANGER! EXTREMELY FLAMMABLE
VAPOR HARMFUL
MAY CAUSE BURNS

Keep away from heat, sparks, and open flame.
Keep container closed.
Avoid breathing vapor.
Avoid contact with skin, eyes, and clothing.
In case of contact, immediately remove all contaminated clothing, including shoes, and flush skin or eyes with plenty of water for at least 15 minutes; for eyes, get medical attention. Wash clothing before re-use. Discard contaminated shoes.

other closures made tight, except that heater coil inlet and outlet pipes (if any) must be left open for drainage. Heater coils must never be used in unloading ethylene oxide. Empty tank cars, drums, and other containers should be returned as promptly as possible, in accordance with instructions received from the shipper. Shipper's routing instructions should always be followed strictly. (See 4.3.4)

3.3.5 Follow ICC Regulations regarding the replacement of closures; condition and labeling of empty containers; condition of empty cars, and placard requirements before returning to the shipper. The ICC "DANGEROUS" placards on sides and ends of tank cars must be removed, or reversed (if in metal placard holders), by the party discharging the tank car. The empty tank car must be offered to the receiving carrier either without placards, or preferably with four (4) "DANGEROUS — EMPTY" placards. Placards must be removed from empty railroad cars of other types.

4. UNLOADING AND EMPTYING

4.1 Health Hazards

Ethylene oxide vaporizes rapidly at ordinary temperatures, and its vapor is moderately toxic by inhalation and is irritating to the eyes and mucous membranes. Ethylene oxide as pure liquid, or in solution, can produce burns of the skin and eyes. (See 8. HEALTH HAZARDS AND THEIR CONTROL.)

4.2 Fire Hazard

Ethylene oxide is an extremely flammable liquid and, as such, introduces a potential fire hazard where it is stored, handled, or used. (See 2.3.2 and 6.2.1 Fire Hazards.)

4.2.1 *EXPLOSION HAZARDS*

Ethylene oxide vapor may explode when exposed to static electricity, electric sparks, excess heat or detonating agents. Dilution of the vapor phase with an inert gas is a recommended safety precaution. (See 2.3.3 and 6.2.2 Explosion Hazards.)

4.3 Tank Cars

Detailed instructions for unloading tank cars containing flammable liquids are set forth in MCA Manual Sheet TC-4. (Also see ICC regulations, Sec. 74.560 to 74.563 inclusive, for unloading tank cars.) A few instructions which are specific for tank cars in ethylene oxide service are given below.

4.3.1 Shipper's instructions should always be followed and all caution markings on both sides of tank and dome should be read and observed.

4.3.2 In the event of a tank car or fitting failure or leak, the shipper should be telephoned or wired immediately for instructions. (See 6.3 Spills and Leakage.)

4.3.3 Tank cars should be electrically grounded to dissipate static or induced lightning charges.

4.3.4 No heat should be applied to the tank car. An inert gas line should be attached to vent connection of the tank car to provide a pressure of 35 psig and not over 65 psig for transfer of the oxide from tank car to receiving tank. Cylinder nitrogen is often used as the pressuring medium in the event a suitable inert gas is not available within the plant. When converted ICC-104 or ARA-IV cars are used under authority of ICC Regulations, Sec. 73.124(5), transfer pressure must not exceed 50 psig. If a pump is utilized, a pressure of 35 psig must be maintained to keep the vapor phase of the tank car in a non-explosive range. (See Figure I for details of unloading arrangement.)

4.3.5 Tank cars in ethylene oxide service are equipped with excess flow check valves. A too rapid opening of the discharge valves will cause the check valves to close. If this should occur, the outlet valve should be closed until the pressure is equalized and the excess flow valve opens.

4.3.6 No air should be allowed to enter the car. The inert gas at 35 psig pressure should be left in the car for the return of the empty tank car. (See 3.3 Disposal and Return Precautions.)

4.4 Insulated Drums (See 4.3.4)

Detailed instructions are supplied by the shipper. (See 4.3.4 Figure I.)

4.4.1 Drums should be unloaded carefully to prevent damage. Drums containing ethylene oxide should be set upright during storage and for unloading.

4.4.2 If any leaking drums are found, they should be removed to a safe location where the leaking can be stopped or the contents transferred. It should always be remembered that ethylene oxide vapors are flammable and toxic. (See 6. HANDLING.)

4.4.3 If it is not practical to locate the insulated drum outdoors during unloading, a vent stack or hood equipped with an exhauster should be installed over the drum.

4.4.4 An inert gas is used to empty a drum of its contents. Heating increases the explosion hazard (See 2.3.3 and 6.2.2 Explosion Hazards). In addition, heating may cause polymer formation.

4.4.5 If ethylene oxide vapor is required by the user, it will be necessary to provide a vaporizer. The size and arrangement of such will be dependent upon the requirements of the user. The vaporizer, however, should be designed to contain a minimum volume of ethylene oxide and to have a maximum surface. (See 6.2.2 Explosion Hazards.) If possible, the vaporizer should be located outside of buildings to prevent the accumulation of ethylene oxide vapors in case of any leakage.

4.4.6 When unloading liquid ethylene oxide from an insulated drum, a total gas pressure of 35-40 psig at 70° F. should be maintained in the drum through the vent connection, and the flow of liquid regulated by the discharge valve. All piping and equipment should be made of steel and properly grounded. (See 6. HANDLING.)

4.4.7 Check valves should be installed in the discharge line to prevent reactants from entering a drum. (See 6. HANDLING.)

4.4.8 If more than 50 psig pressure is desired by the user in a manufacturing process, it will be necessary to install a pump because the safe working pressure of the insulated drum is only 50 psig.

4.4.9 When the drum has been emptied of its contents, an inert gas pressure of 35 psig at 70°F. should be left in the drum for return to the shipper. No air should be allowed to enter the drum. (See 3.3.2)

4.4.10 If the drum is emptied only partially of its contents at any one usage, total gas pressure of 35 psig at 70° F. should be left in the drum for storage. (See 5. STORAGE.)

4.5 Small Cylinders

4.5.1 Precautions generally applied to use of small cylinders (ICC-3B300 and ICC-4B400) of flammable liquids should be used.

4.5.2 A water bath heated to a maximum of 50° C. (122° F.) may be used to empty a small uninsulated container by means of the vapor pressure of the ethylene oxide.

4.5.3 Check valves must be installed in feed lines from the cylinder to prevent the reactants from entering the cylinder.

4.5.4 When the cylinder is empty, the valve should be closed. Air should not be allowed to enter the container.

5. STORAGE

5.1 Hazards

5.1.1 *HEALTH HAZARDS*

Ethylene oxide vaporizes rapidly at ordinary temperatures, and its vapor is moderately toxic by inhalation and is irritating to the eyes and mucous membranes. Ethylene oxide as pure liquid, or in solution, can produce burns of the skin and eyes. (See 8. HEALTH HAZARDS AND THEIR CONTROL.)

5.1.2 *FIRE HAZARDS*

Ethylene oxide is an extremely flammable liquid and, as such, introduces a potential hazard where it is stored, handled, or used. (See 2.3.2 and 6.2.1 Fire Hazards.)

5.1.3 *EXPLOSION HAZARDS*

If not diluted with an inert gas, ethylene oxide vapor may explode when ignited within a confined space. (See 2.3.3 and 6.2.2 Explosion Hazards.)

5.1.4 *CORROSION*

Ethylene oxide is noncorrosive.

5.1.5 *VOLATILITY*

Ethylene oxide is very volatile and should be stored under pressure with adequate cooling. (See 2.2 Important Physical and Chemical Properties and 5.2 Conditions of Storage.)

5.1.6 *TEMPERATURE REQUIREMENTS*

Ethylene oxide in storage tanks should be maintained at a temperature not exceeding 30° C. (86° F.). Ethylene oxide in insulated drums or small containers should be stored in a cool, well-ventilated area. (See 5.2 Conditions of Storage and 6.2.2 Explosion Hazards.)

5.2 Conditions of Storage

5.2.1 *MATERIAL AND TYPE OF CONSTRUCTION.*

All piping (including instrument leads), storage tanks, relief devices and equipment employed to handle ethylene oxide should be of steel or stainless steel and designed to have a working pressure of at least 50 psig with a safety factor conforming to the A.S.M.E. Code. Shut-off valves and control valves should be of steel or stainless steel designed for working pressures of 150 psig or over. Copper or other acetylide-forming metals, such as silver, magnesium and their alloys should not be used as materials of construction for equipment handling ethylene oxide. Mercury-filled instruments should be provided with mercury traps and an inert gas purge which is free of acetylene and carbon dioxide. All-welded construction is preferred to riveted construction. Storage tanks should be equipped with cooling coils and should be well insulated. All liquid inlet lines should enter or lie extended to the bottom of the vessel to prevent the generation of static electricity. All equipment should be properly grounded and an efficient water spray system should be installed. Adequate diking and drainage should be provided in the tank area to confine and dispose of the liquid in case of tank rupture.

5.2.2 *ISOLATION*

Local building codes should be followed strictly. Ethylene oxide storage tanks should be isolated from continuous ignition sources such as boiler houses. If possible, storage tanks should be located outside of buildings. Insulated drums containing ethylene oxide should be stored always in a vertical position, outside of buildings, and in an isolated and well-ventilated area. It is preferable to store the containers in the open, but provision should be made to shield them from the direct rays of the sun and to prevent accumulation of dirt, snow, water, or ice on valves or safety devices. The use of an open-sided storage shed is suggested.

5.2.3 *COMPATIBILITY WITH OTHER MATERIALS*

Storage tanks in ethylene oxide service should be used only for ethylene oxide unless thoroughly cleaned and purged. (See 6.8 Tank and Equipment Cleaning and Repair.) Ethylene oxide reacts exothermically with such compounds as alcohols, amines, ammonia, and organic and mineral acids. Before a tank is placed in ethylene oxide service, it should be cleaned thoroughly, flushed with water and dried. Before ethylene oxide is placed in the tank, the vessel should be purged with an inert gas until free of air.

5.2.4 *VAPOR-PROOF OR EXPLOSION-PROOF REQUIREMENTS*

All electrical equipment, motors, lights, and flashlights used in an area in which oxide is stored or handled should conform to the National Electrical Code and should be vapor-tight.

5.2.5 *EXPLOSION VENTING REQUIREMENTS*

An adequate system for normal and emergency venting should be installed. All vent lines should extend to a safe area. The point of outlet should be equipped with an approved flame arrestor. Relief valves should be installed in pairs to facilitate periodic testing and repairing. The vent line should be equipped with a connection for emergency purging with steam, nitrogen or carbon dioxide for the extinguishment of any fire occurring on the outlet side of the flash arrestor.

5.2.6 *VENTILATION*

All storage areas should be provided with continuous ventilation. Pits, depressions and basements should be avoided.

5.2.7 *PROTECTION FROM ELECTRICAL STORMS*

Storage tanks for ethylene oxide should be protected from electrical storms and induced static electricity by grounding of all equipment.

5.2.8 *PROTECTION FROM INTERNAL IGNITION*

Storage tanks and other equipment should be maintained under an inert atmosphere in a non-flammable range during all transfers, as well as during stationary conditions, to prevent possible ignition in the vapor phase within the vessel. Vessels should be provided with bottom inlets under the liquid, or tangented nozzles to prevent static sparks. (See 5.2.1) (See 6.2.2 Explosion Hazards.)

6. HANDLING

6.1 Health Hazards

Ethylene oxide vaporizes rapidly at ordinary temperatures, and its vapor is moderately toxic by inhalation and is irritating to the eyes and mucous membranes. Ethylene oxide as pure liquid, or in solution, can produce burns of the skin and eyes. (See 8. HEALTH HAZARDS AND THEIR CONTROL.)

6.2 Fire, Explosion, and Polymerization Hazards

6.2.1 *FIRE HAZARDS*

Ethylene oxide should be handled with all precautions generally observed in handling flammable liquids. Fires involving large quantities of liquid are difficult to extinguish, although ethylene oxide is soluble in water. The fire will continue to burn until the liquid is diluted with approximately 22 volumes of water to one of oxide. Most small fires can be extinguished with carbon dioxide or dry chemical agents if properly applied. Adequate fire extinguishing equipment, fixed and portable, should be provided. Diking and drainage should be provided for confining and disposing of the liquid in case of tank rupture.

6.2.2 *EXPLOSION HAZARDS*

Liquid ethylene oxide is quite stable to explosion initiators but, as a vapor, ethylene oxide may undergo rapid decomposition if an explosion is initiated. This action is accompanied by the liberation of a considerable amount of energy (See 2.2 Important Physical and Chemical Properties) and, if in a confined space, will produce an increase in pressure of 16 to 50 (plus) times the initial pressure. The pressure ratio varies with the ratio of volume to surface of the containing vessel. Detonating acetylides, static electricity, excess heat, "hot spots," open flames, or other detonators may explode ethylene oxide vapors. If a vessel containing ethylene oxide is not insulated or protected by a film of water and becomes enveloped by fire, the vapor may be heated quickly above the auto-ignition temperature of 571° C. (1060° F.). (See 2.2 Important Physical and Chemical Properties.) Ignition within a vessel containing ethylene oxide may be prevented by proper dilution of the vapor phase with an inert gas. Any inert gas selected should be free of such impurities as air, acetylene, sulfur, hydrogen sulfide, water, ammonia, or carbon dioxide. (Dilution data, composition versus temperature and pressure, are available for common inert gases.) Ignition from fire exposure should be guarded against by adequate insulation and automatic water spray systems. Storage tanks and processing equipment handling ethylene oxide should be free from air because air reduces the percentage of oxide vapor required for an explosive mixture.

6.2.3 *POLYMERIZATION HAZARDS*

Ethylene oxide may rearrange and/or polymerize violently, liberating large quantities of heat. A few of the most notable catalysts for this type of reaction are: anhydrous iron, tin, and aluminum chlorides; pure iron and aluminum oxides; metallic potassium; alkali metal hydroxides; acids and organic bases. The speed of the reaction varies with the purity of the reactants, the temperature, the relative amount of each reactant, and the method of application.

6.3 Spills and Leakage

6.3.1 Frequent inspections of equipment and vessels containing ethylene oxide should be made to detect or prevent leaks.

6.3.2 If leaks or spills occur, only properly protected personnel should remain in the area (See 8.3 Personal Protective Equipment).

6.3.3 All spills should be flushed away promptly with a large quantity of water (See 6.2.1 Fire Hazards). All openings in sewer system should be trapped for segregation and extinguishment. All sources of ignition should be removed.

6.3.4 If possible, increased ventilation should be provided. Inhalation of vapors should be avoided. (See 8. HEALTH HAZARDS AND THEIR CONTROL.)

6.3.5 All articles of clothing, including shoes, wet with ethylene oxide or exposed to oxide vapors should be removed immediately and the body washed to remove any of the ethylene oxide which has penetrated the clothing. Clothing should be washed before re-use.

6.3.6 A leaking container should be removed to an isolated, well-ventilated area and the contents transferred to other suitable containers. Unloading rules set forth in Section 4 should be observed.

6.3.7 In the event of a tank car leakage, dilute leakage with large quantity of water, and make necessary repairs, if possible. The supplier should be telephoned or wired immediately for specific instructions.

6.4 Employee Education and Training

6.4.1 Workers who handle ethylene oxide, or may be exposed to it in any form, should be instructed carefully in accepted methods of handling and be familiar with the protective equipment required for safe handling. Instruction should stress the hazard for any fire or explosion and contact of the material with the skin and eyes, and avoiding inhalation of the vapors.

6.4.2 All workers should be familiar with the location of safety showers, alarm boxes, emergency ventilation system and hose lines.

6.4.3 Each employee should be reinstructed periodically in the hazards involved and proper emergency measures to take.

6.5 Personal Protective Equipment

6.5.1 *AVAILABILITY AND USE*

Personal protective equipment is not an adequate substitute for good, safe, working conditions, adequate ventilation and intelligent conduct on the part of employees working with ethylene oxide. Such equipment may protect the individual wearing it while others in the area may be exposed to danger. The correct usage of personal protective equipment requires the education of the worker in the proper employment of the equipment available to him. (See 6.4 Employee Education and Training.) Under conditions which are sufficiently hazardous to require protective equipment, the use of it should be supervised.

The following personal protective equipment should always be used for the purposes mentioned, and as specified in 8. HEALTH HAZARDS AND THEIR CONTROL and in other sections of this publication.

6.5.2 *EYE PROTECTION*

6.5.2.1 *Chemical Safety Goggles*: Cup-type or rubber-framed, vapor proof goggles, equipped with approved impact resistant glass or plastic lenses, should be worn whenever there is danger of the material (in liquid or vapor form) coming in contact with the eyes. Goggles should be carefully fitted by adjusting the nose piece and head band to insure maximum protection and comfort.

6.5.3 *RESPIRATORY PROTECTION*

Respiratory protective equipment must be carefully maintained, inspected, cleaned and sterilized at regular intervals, and always before use by another person. Personnel wearing such equipment must be carefully instructed as to its operation and limitations.

6.3.5.1 Air-supplied masks, equipped with full face pieces, must be worn for protection under the following conditions:

(a) In emergencies, when the vapor concentration is not definitely known.

(b) When the harmful vapor concentration is over 2 per cent by volume.

(c) When the oxygen content of the air may be less than 16 per cent by volume.

(d) When the exposure period is to be over 30 minutes' duration.

(e) In tank and equipment cleaning and repair work, when (a), (b), (c) and (d) apply.

6.5.3.2 Only masks approved by the Bureau of Mines should be used, and the manufacturers' instructions must be carefully followed. Types generally available include:

(a) Air-line masks supplied by plant compressed air are suitable for use only where conditions will permit safe escape in case of failure of the compressed air supply. Such masks should be used only in conjunction with a suitable reducing or demand-type valve and filter, and with excess pressure relief valve. The compressed air should be checked frequently to make certain that harmful gases such as from the decomposition of the lubricating oil used in the compressor or impure air supply are not present.

(b) Positive-pressure hose masks supplied by externally lubricated blowers are usually preferred to the air-line type. Since these masks also depend on a remote air supply, they should be used only where conditions will permit safe escape in the event of air supply failure. Care must be taken to locate the source of the blower air in an area which is free of air contaminants.

(c) Self-contained breathing apparatus which permits the wearer to carry a supply of air in the cylinder allows for greater mobility. The length of time a self-contained breathing apparatus provides protection varies according to the amount of air supply carried. In tank work, where small manholes are encountered, a self-contained breathing apparatus is usually unsuitable because of its bulk.

6.5.3.3 Industrial canister-type gas masks, approved by the Bureau of Mines, fitted with the proper canister for absorbing ethylene oxide vapor, (or gas), and equipped with full face pieces, will afford protection against concentrations not exceeding 2 per cent by volume when used in accordance with the manufacturer's instructions. The oxygen content of the air must be not less than 16 per cent by volume. The masks should be used for relatively short exposure periods only, i.e., less than 30 minutes. They may not be suitable for use in an emergency since, at that time, the actual vapor concentration is unknown and it may be very high. The wearer must be warned to leave the contaminated area immediately on detecting the odor of a harmful vapor. This is an indication that the mask is not functioning properly or that the vapor concentration is too high.

NOTE: When carbon monoxide may be encountered in addition to ethylene oxide, the mask should be equipped with an all-purpose canister and a timing device as approved by the U.S. Bureau of Mines.

6.5.4 *HEAD PROTECTION*

6.5.4.1 Safety or "hard" hats will provide protection against accidental liquid leaks, falling tools and other objects.

6.5.4.2 Brimmed felt hats may be substituted for a safety hat where the danger of falling objects is remote.

6.5.5 *FOOT PROTECTION*

Leather or rubber safety shoes with built-in steel toe caps are recommended. Rubbers may be worn over leather safety shoes.

NOTE: Ethylene oxide may penetrate leather and rubber, but up-to-date rubber is probably the best available protective material.

6.5.6 *BODY, SKIN AND HAND PROTECTION*

6.5.6.1 Suits made of a suitable protective material, and properly designed should be used to provide complete body protection, when necessary.

6.5.6.2 Aprons made of suitable protective material should be used for protection against accidental contact.

6.5.6.3 Gloves made of suitable protective material should be worn to protect the hands from ethylene oxide.

6.5.6.4 Sleeves made of suitable protective material should be worn when the need for complete arm protection is indicated.

6.5.6.5 Life harness and life line should be worn by men working in tanks or other confined spaces to facilitate rescue.

6.5.6.6 Whenever necessary, facilities for personal cleanliness should be provided and time allowed for thorough washing before lunch and at the end of the work day.

6.6 Engineering Controls

6.6.1 Because ethylene oxide is an extremely flammable liquid and the vapor is explosive and toxic under certain conditions, processes should not be located near open flames, high temperatures or congested areas. (See 5.2 Conditions of Storage.)

6.6.2 Processes should be designed so that the operator is not exposed to direct contact with ethylene oxide or its vapor. The technical problems of designing equipment, providing adequate ventilation, and formulating operational procedures which promise maximum security and economy, can be handled best by engineers or other competent personnel. The manufacturers of ethylene oxide, and of the equipment in which it is to be used, are always prepared to help with these problems.

6.6.3 For each installation, a written set of operating instructions should be prepared and posted adjacent to the operation. The procedure should be checked frequently by the supervisor in order to maintain proper controls.

6.6.4 In the handling of ethylene oxide or operation of any type of ethylene oxide system, all valves, pipe lines, vents, safety devices, etc., should be so located that they can be readily inspected and cleaned periodically to prevent plugging and should always be in proper order and condition before the operation is started. All handling and storage equipment should be located away from all possible source of sparks, flames and heated surfaces. All charging and discharging pipes should enter through, or extend to, the bottom of all containers to minimize vaporization of the liquid and possible generation of static electricity. (See also 5.2.7 and 5.2.8.)

6.6.5 It is essential for safety that equipment be used and maintained as recommended by the manufacturer and that a periodic test schedule of the equipment, including safety devices, should be followed.

6.6.6 The manufacturer's recommendation as regards the unloading and loading of shipping containers should be followed with caution to avoid static from streams in tanks.

6.6.7 Due to the tendency of ethylene oxide to leak through even the smallest opening, welded rather than threaded connections are recommended on all equipment containing this chemical.

6.7 Ventilation

6.7.1 If the workroom or operating area is separate from ethylene oxide storage or processing equipment, general ventilation is adequate. For emergencies, however, the area should be provided with mechanical exhaust ventilation.

6.7.2 In the processing or storage area, if outside location is impracticable, special emergency equipment for ventilation is necessary under abnormal conditions, such as leaks or spills.

6.7.3 Twelve changes of air per hour are considered adequate for buildings housing storage or processing equipment for flammable liquids, vapors, or gases under pressure.

6.7.4 Buildings of substantial construction should have at least 1 sq. ft. of door, window, or non-rigid roof area for each 35 cu. ft. of volume to prevent serious structural damage in the event of explosion within the building.

6.7.5. A remote manual control should be provided for forced ventilation systems, to be used in the event of an emergency.

6.8 Tank and Equipment Cleaning and Repairs

6.8.1 Cleaning or making repairs inside of equipment in which ethylene oxide is contained is particularly hazardous because of its toxicity and flammability. (See 8. HEALTH HAZARDS AND THEIR CONTROL.)

6.8.2 Safety respiratory apparatus, protective clothing, spark-proof tools, and explosion-proof lights should be provided for repair or cleaning crews.

6.8.3 Written approval of supervisor should be procured by the repair or cleaning crews.

6.8.4 The liquid ethylene oxide should be pumped out or transferred. Any pressure on the equipment should be vented to a safe area or through a scrubber. The equipment should be filled with water, drained, and thoroughly washed before it is entered for any inspection or repairs.

6.8.5 All connections to vessels should be blanked off and the air in the tank tested with a combustible gas indicator approved for ethylene oxide. Gas tests should be repeated from time to time if continued work within the equipment is necessary.

6.8.6 A "watcher" supplied with the specified safety equipment should be stationed outside the equipment entrance to keep the men inside under constant observation. Additional men should be available for rescue work. (See 8.3.2)

6.8.7 Special ventilation is recommended during the entire time men are cleaning, repairing, or inspecting the equipment.

6.8.8 Before the equipment is returned to ethylene oxide service, an inert gas should be used to purge out all of the air. If the gas used for purging forms a flammable gas-air mixture, the equipment should be filled with water and then blown with the gas, vented to a safe location, until dry.

6.9 Repackaging

This entire manual should be carefully reviewed by the repacker so that he may become familiar with the hazardous properties of ethylene oxide and the safeguards which should be taken to handle it safely. Only ICC specification containers should be used (See 3.1 Type and Size). The containers should be cleaned thoroughly and dried, and they should be labeled properly (See 3.2 Label or Identification).

6.10 Use in Chemical Reactions

6.10.1 Because of the explosive characteristics of ethylene oxide vapor and the generally exothermic nature of the reaction of the liquid with various materials, precautions are required when feeding it into a reaction mixture.

6.10.2 The vapor phase of reactions under pressure should be diluted or blanketed with an inert gas. (See 6.2.2 Explosion Hazards.)

6.10.3 Proper agitation to assure constant and complete mixing should be provided.

6.10.4 Because the control of temperature and pressure is important, proper instrumentation and some means of cooling the reaction should be provided.

6.10.5 Normal and emergency venting of adequate capacity should be provided.

6.10.6 Check valves should be installed in feed lines in an effort to prevent the reactants from entering a cylinder, vaporizer, or any vessel containing pure ethylene oxide.

6.10.7 All piping and equipment should be made of steel. Do not use copper, silver, magnesium, and their alloys as materials of construction for equipment handling ethylene oxide.

7. WASTE DISPOSAL

7.1 Waste mixtures containing ethylene oxide should not be allowed to enter drains or sewers where there is danger of the vapors becoming ignited. All openings in sewer systems should be trapped for segregation and extinguishment. (See 6.2 Fire, Explosion, and Polymerization Hazards and 6.3 Spills and Leakage.)

7.2 When it becomes necessary to dispose of ethylene oxide as such, it is preferable to do so as a vapor, venting to a safe location. (See 5.2.5 Explosion Venting Requirements.)

7.3 All polymeric wastes are water soluble and, as such, present no major problem. Disposal of these materials, however, depends to a great extent upon local conditions. All Federal, State, and local regulations regarding health and pollution should be followed.

8. HEALTH HAZARDS AND THEIR CONTROL

This section includes a description of the principal health hazards of ethylene oxide, recognized first aid procedures and information of interest to laymen and physicians.

8.1 Hazards

8.1.1 *GENERAL*

The usual contact that occurs in handling ethylene oxide is by inhalation of its vapor. Exposure to low concentrations of vapor often results in delayed nausea and vomiting. Exposure even to low concentration, if continuous, will result in a numbing of the sense of smell; thus harmful concentration may be reached, without warning because of odor. High concentrations of ethylene oxide can produce edema of the lung and irritation of the eyes and mucous membranes.

Liquid ethylene oxide can produce eye burns but when spilled on exposed skin, is generally not immediately irritating, but continued contact may cause burns. When it is spilled on clothing or in the shoes, it is capable of producing a delayed burn of the skin if the wet clothing and shoes are not removed promptly. Rapid evaporation of ethylene oxide on the skin is capable of producing an effect like frostbite.

8.1.2 *ACUTE TOXICITY*

8.1.2.1 *Systemic Effects*

When excessive amounts of ethylene oxide are inhaled, they have a general anesthetic effect as well as causing coughing, due to irritation of the respiratory system. The victim may become nauseated and vomit.

8.1.2.2 *Local Effects*

The vapor will cause eye and nasal irritation when present in excessive amounts. The liquid or solutions on the exposed skin do not cause skin irritation immediately, but when spilled in the shoes or on the clothing, delayed skin burns can occur if the clothing and shoes are not promptly removed. The liquid or solutions may cause severe eye burns. Vapor has been known to produce skin irritation and burns from its absorption by perspiration in areas of heat and moisture about the body. (See 8.4.2.2 Skin Contact and 8.4.2.3 Contact With Eyes.)

8.1.3 *CHRONIC TOXICITY*

No cases of chronic poisoning due to ethylene oxide have been reported.

8.2 Prevention and Control

Ethylene oxide does not present a serious industrial health hazard provided workers are effectively instructed and adequately supervised in the proper handling of the chemical.

8.2.1 *EMPLOYEE EDUCATION*

(See 6.4 Employee Education and Training.)

8.2.2 *VENTILATION*

A maximum allowable concentration of 100 parts per million of ethylene oxide by volume in air has been proposed for an eight-hour working day exposure. Ventilation should be adequate to keep atmospheric concentration below 100 parts per million in places where ethylene oxide is being handled and employees are exposed.

8.2.3 *PRE-EMPLOYMENT PHYSICAL EXAMINATION*

Those who are to work with ethylene oxide should be given a thorough physical examination. In general, asthmatic individuals and those suffering from acute or chronic chest infections should not be exposed to ethylene oxide.

8.2.4 *PERIODIC PHYSICAL EXAMINATIONS*

Workers exposed to ethylene oxide need no special type of specific examination except that attention should be directed to the lungs.

8.3 Personal Protective Equipment

8.3.1 Personal protective equipment is not an adequate substitute for safe working conditions and intelligent conduct on the part of employees who work with ethylene oxide. The employees should be carefully trained and carefully supervised in the correct use of personal protective equipment.

8.3.2 Severe exposures to ethylene oxide may occur in tank and equipment cleaning and repairs, in extensive spillage of the material, or in cases of failure of piping and equipment. Employees who may be subject to such exposures should be provided with proper eye, respiratory, skin, and mucous membrane protection as follows:

(a) Suitable gas-tight chemical safety goggles.

(b) Rescue harness and lifeline for those entering the tank or enclosed storage space. (An assistant provided with indicated protective equipment should be present when such equipment is used.)

(c) Hose mask with hose inlet in vapor-free atmosphere. Air-line masks with proper reducing valve and filter, suitable for use only where conditions will permit safe escape in case of failure of compressed air supply.

(d) Where the period of exposure is not longer than 30 minutes, and when the oxygen content of the atmosphere is above 16 per cent by volume, and concentration of ethylene oxide does not exceed 2 per cent by volume in the air, workers may wear full-faced industrial gas masks approved by the United States Bureau of Mines, with canisters approved for use in the presence of ethylene oxide. Note: 2% is dangerously near the lower explosive limit of 3% for ethylene oxide.

(e) Rubber gloves and apron.

(f) Rubber shoes or boots.

8.3.4 Reliable safety equipment manufacturers can supply appropriate protective equipment if they are informed accurately of the particular product in use. (See 6.5 Personal Protective Equipment.)

8.4 First Aid

8.4.1 First aid should be started at once in cases of contact with excessive amounts of ethylene oxide. Workers presenting symptoms or signs of ethylene oxide poisoning should be removed at once from the contaminated area. A physician should be called at once, notifying him of nature of case and location of the patient.

8.4.2 *SPECIFIC ACTIONS*

8.4.2.1 *Inhalation*

In case breathing has stopped, effective artificial respiration such as that obtained by the prone pressure or by the Eve rocking method* should be started immediately. If oxygen inhalation apparatus is available, oxygen should be administered, but only if one familiar with the operation of such apparatus is present to administer it. A physician should be called at once. In order to prevent the development of severe lung congestion (pulmonary edema), 100 per cent oxygen should be administered as soon as possible after a severe exposure. Oxygen administration is most effective if expiration is made against a positive pressure of 4 cm. (about 1¼ inches) of water. This may be accomplished readily by use of a rubber tube connected to the outlet valve of a snugly fitting face mask and inserted to a depth of not more than 4 cm. below the surface of water in a suitable container. (Special masks are obtainable with adjustable gauges which regulate the positive pressure from 1 to 4 cm.) The pressure resisting exhalation should be adjusted to the patient's tolerance by varying the depth of the end of the tube below the water's surface. Oxygen inhalation must be continued as long as necessary to maintain the normal color of the skin and mucous membranes. In cases of severe exposure, the patient should breathe 100% oxygen under positive exhalation pressure for one-half hour periods every hour for at least three hours. If there are no signs of lung congestion at the end of this period, and if breathing is easy and the color is good, oxygen inhalation may be discontinued. Throughout this time, the patient should be kept comfortably warm, but not hot.

Milder exposures to ethylene oxide vapors at times produce nausea and vomiting. In cases presenting such symptoms, they should be placed in bed and given warm water in sufficient amounts to aid in washing out their stomachs. A physician should be called.

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*See F. C. Eve, Journal of American Medical Association (April 1, 1944).

8.4.2.2 *Skin Contact*

All clothing contaminated with liquid ethylene oxide should be removed at once. Clothing, including shoes, should not be worn again until free from ethylene oxide. Shoes can seldom be decontaminated. All affected areas of skin should be thoroughly washed with soap and water.

It has been noted that if shoes are worn which have been soaked in ethylene oxide, delayed skin burns can occur. Even weak solutions which contaminate clothing can produce the same effect, particularly in such areas as the genital region. These burns form blebs or water blisters out of proportion to the amount of skin damage and are usually healed in a week or 10 days if properly treated. (See 8.5)

8.4.2.3 *Contact With Eyes*

Ethylene oxide, as liquid or vapor, is capable of producing eye damage. Should it reach the eyes, the eyes should be irrigated immediately and copiously with water for fifteen minutes. The eyelids should be held apart during the irrigation to insure contact of the water with all the tissues of the surface of the eyes and lids. Should eye irritation persist, the eyes should be irrigated for a second period of 15 minutes and a physician, preferably an eye specialist, should be called in attendance.

8.4.2.4 *Taken Internally*

Due to the nature of ethylene oxide, it is very unlikely that any of it could be taken internally, but if a person has swallowed liquid ethylene oxide or its solutions, he should be made to vomit, if conscious, by having him drink a glassful or more of lukewarm water in which a teaspoonful of salt to the glassful has been dissolved; or a similar amount of warm soapy water may be used. If necessary, the patient should be encouraged to stick his finger down his throat to induce vomiting. When possible, vomiting should be induced at least three times. Following this, a tablespoonful of Epsom salt dissolved in a glass of water should be given. A physician should be called at once.

8.5 Suggestions for Medical Treatment

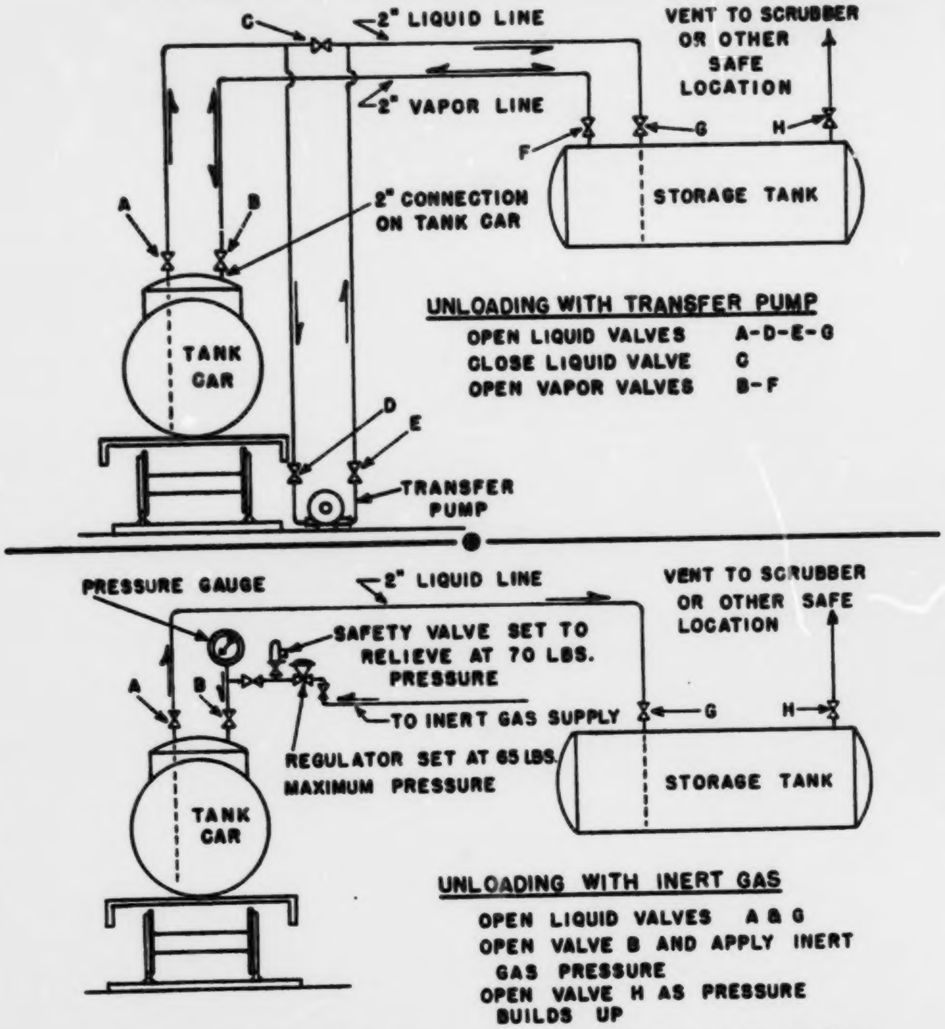
Through unpublished reports, it has been found that for persistent nausea and vomiting which may result from inhalation of ethylene oxide, an intramuscular injection of sodium phenobarbital gr. ii is very helpful in controlling such symptoms.

For skin burns resulting in the formation of blebs, if the blebs are evacuated and solid petrolatum dressings are applied, the healing is usually quite prompt. The bleb formation is out of proportion to the actual damage to tissue as the burns are, as a general rule, quite superficial.

The medical information in this publication has been supplied by the Medical Advisory Committee of the Manufacturing Chemists' Association, Inc.

FIGURE I.

UNLOADING LIQUID ETHYLENE OXIDE


C
2" LIQUID LINE
VENT TO SCRUBBER OR OTHER SAFE LOCATION
2" VAPOR LINE
F
G
H
STORAGE TANK
A
B
2" CONNECTION ON TANK CAR
TANK CAR
D
E
TRANSFER PUMP
PRESSURE GAUGE
2" LIQUID LINE
VENT TO SCRUBBER OR OTHER SAFE LOCATION
SAFETY VALVE SET TO RELIEVE AT 70 LBS. PRESSURE
A
B
TO INERT GAS SUPPLY
G
H
REGULATOR SET AT 65 LBS. MAXIMUM PRESSURE
STORAGE TANK
TANK CAR

UNLOADING WITH TRANSFER PUMP

OPEN LIQUID VALVES	A-D-E-G
CLOSE LIQUID VALVE	C
OPEN VAPOR VALVES	B-F

UNLOADING WITH INERT GAS

OPEN LIQUID VALVES A & G
OPEN VALVE B AND APPLY INERT GAS PRESSURE
OPEN VALVE H AS PRESSURE BUILDS UP

NOTE: THE PRESSURES SHOWN APPLY TO ICC-104A, 104A-W & ARA-IVA TANK CARS.

E.3.2 National Safety Council (NSC) Industrial Safety Data Sheets

Safety data sheets published by the National Safety Council, 425 Michigan Avenue, Chicago, Illinois 60611, are available at a cost of $0.45 per sheet (discounts for quantities of 10, 100, and 1000; NSC members receive an additional 20% discount and government agencies an additional 10%). The chemicals for which safety data sheets are available are the following. Order copies by name and file number, as shown.

Exhibit E-7 is an NSC safety data sheet for Anhydrous Ammonia.

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Data Sheet 251
Revision A
(Extensive)

ANHYDROUS AMMONIA

This data sheet was revised by the Petroleum Section, National Safety Council, 425 N. Michigan Ave., Chicago, Ill. 60611, and is published by the Council.

HAZARDS WHICH surround the handling and use of anhydrous ammonia* create a hazard sometimes taken too lightly. Subsequent paragraphs of this data sheet will spell out the various hazards involved when working with or using anhydrous ammonia, and disclose the measures to follow to avoid personal impairment.

Physical properties

2. Under normal conditions of temperature and pressure anhydrous ammonia is a stable compound and a colorless gas having a strong unmistakable odor. The physical properties of anyhydrous ammonia are listed in Table I.

3. The relation between temperature and vapor pressure, density, specific gravity, and latent heat of vaporization of liquid anhydrous ammonia is given in Table II. Under ordinary conditions ammonia is a very stable compound. At temperatures of 840 to 930 F (450 to 500 C), it begins to decompose to form nitrogen and hydrogen.

Containers

4. *Tank cars:* Some ammonia is moved in tank cars (ICC 106A500) which are multi-unit cars consisting of a number of cylinder-type containers which are removed from the car for filling and emptying.

5. The largest movement by tank car is in single unit tank cars. These cars are practically identical to those used in LP-gas service, except they have no brass or bronze fittings. However, there are many of these cars in "dual" service, that is, they may be used either for anhydrous ammonia or LP-gas. The dual service cars have fittings suitable for anhydrous ammonia and must be thoroughly purged after having been used for anhydrous ammonia before being placed in LP-gas service, to prevent any ammonia from passing into LP-gas systems which have brass or bronze valves or fittings.

6. These welded tank cars have no dome in the usual sense of the word, and have no bottom outlet. All valves and fittings for loading

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**The term anhydrous ammonia refers to the compound formed by the combination of two gaseous elements, nitrogen and hydrogen, in the proportion of one part nitrogen to three parts hydrogen by volume. It is not to be confused with aqua ammonia which is a solution of ammonia gas in water.*

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Exhibit E-7
NSC Safety Data Sheet on Anhydrous Ammonia

TABLE I
PHYSICAL PROPERTIES OF ANHYDROUS AMMONIA

Molecular symbol	NH_3
Molecular weight	17.032
Boiling point at one atmosphere (one atmosphere = 14.7 psi)	—28 F (—33.4 C)
Melting point at one atmosphere	—107.9 F (—77.4 C)
Critical temperature	271.4 F (133.0 C)
Critical pressure	1657 psia
Latent heat at —28 F and one atmosphere	589.3 Btu per lb
Relative density of vapor compared to dry air at 32 F (0 C) and one atmosphere	0.5970
Vapor density at —28 F (—33.4 C) and one atmosphere	0.05555 lb per cu ft
Specific gravity of liquid at —28 F (—33.4 C) compared to water at 39.2 F (4 C)	0.6819
Liquid density at —28 F and one atmosphere	42.57 lb per cu ft
Specific volume of vapor at 32 F and one atmosphere	20.78 cu ft per lb
Flammable limits by volume in air at atmosphere pressure	16 to 25 per cent
Ignition temperatures (in a standard quartz bomb)	1562 F (850.0 C)

and unloading are attached to a manhole cover plate located on the top of the tank.

7. A steel dome-like housing protects the valves and fittings from physical damage. A designated vapor space is one-foot above the liquid level for expansion in case the liquid temperature rises after loading. The fittings on each tank generally include:

a. Two liquid eduction lines extending to the bottom of the car;
b. one line to the vapor space; and
c. a relief valve.

Most cars (all of those in dual service) also have:

a. One sampling line;
b. a gauging device for determining the liquid level in the tank; and
c. a thermometer well.

8. On most of the cars (those in dual service), all inlet and outlet connections are equipped with excess flow valves (or a remotely operated, quick-closing valve) except the relief valve is never equipped with an excess flow valve, as it prevents proper functioning of this safety device. The relief valve is spring-loaded and reseats itself after the excess pressure has dissipated.

9. *Tank trucks:* More and more anhydrous ammonia is being transported in tank trucks. The tanks are built in accordance with ASME Code requirements. All loading and unloading connections are provided with either an excess flow valve or an automatic quick-closing internal valve. The tanks are protected from excessive pressures by spring-loaded safety relief valves and all valves and fittings are protected from physical damage by a suitable steel guard.

10. *Cylinders:* Cylinders should be maintained, filled, packaged, marked, labeled, and shipped to comply with current ICC regulations (Title 49 and ANSI 48, "Standard Method for Marking Portable Compressed Gas Containers") to identify the material contained.

11. Cylinders should be stored in an area free from combustible material and in a manner so as to prevent external corrosion, and to protect them from moving vehicles or external damage. Any cylinder which is designed to have a valve protection cap should have the cap securely in place when the cylinder is not in service. A rack or chain should be used to hold cylinders in place. There are two types of cylinders: bottle type, and tube type. Cylinders filled in accordance with ICC regulations will become liquid full at 145 F (62.8 C). Cylinders should be protected from radiant heat, steam piping, and open flame.

Unloading procedures

12. *Unloading tank trucks:* The steps to follow when unloading anhydrous ammonia tank trucks will vary depending on the plant and the size of the truck. The proced-

TABLE II PROPERTIES OF LIQUID AMMONIA AT VARIOUS TEMPERATURES*

Temperature (F.)	Vapor Pressure (psig) Col. 1	Liquid Density (lbs. per cu. ft.) Col. 2	Liquid Density (lbs. per U.S. gal.) Col. 3	Liquid Density (lbs. per gal. Imp.) Col. 4	Specific Gravity of Liquid (Compared to water at 4C.) Col. 5	Latent Heat (Btu per lbs.) Col. 6
—28	0.0	42.57	5.69	6.83	0.682	589.3
—20	3.6	42.22	5.64	6.77	.675	583.6
—10	9.0	41.78	5.59	6.70	.669	576.4
0	15.7	41.34	5.53	6.63	.663	568.9
10	23.8	40.89	5.47	6.56	.656	561.1
20	33.5	40.43	5.41	6.49	.648	553.1
30	45.0	39.96	5.34	6.41	.641	544.8
40	58.6	39.49	5.28	6.33	.633	536.2
50	74.5	39.00	5.21	6.26	.625	527.3
60	92.9	38.50	5.14	6.18	.617	518.1
70	114.1	38.00	5.08	6.10	.609	508.6
80	138.3	37.48	5.01	6.01	.600	498.7
90	165.9	36.95	4.94	5.93	.592	488.5
100	197.2	36.40	4.87	5.84	.583	477.8
110	232.3	35.84	4.79	5.75	.573	466.7
120	271.7	35.26	4.71	5.66	.565	455.0
130	315.6	34.66	4.63	5.56	.555	443
140	364.4	34.04	4.55	5.46	.545	430

From Compressed Gas Association, Inc., Pamphlet G-2

*(Data for Columns 1, 2 and 6 taken from Bureau of Standards Circular No. 142. Values for Columns 3, 4 and 5 calculated from Column 2.)

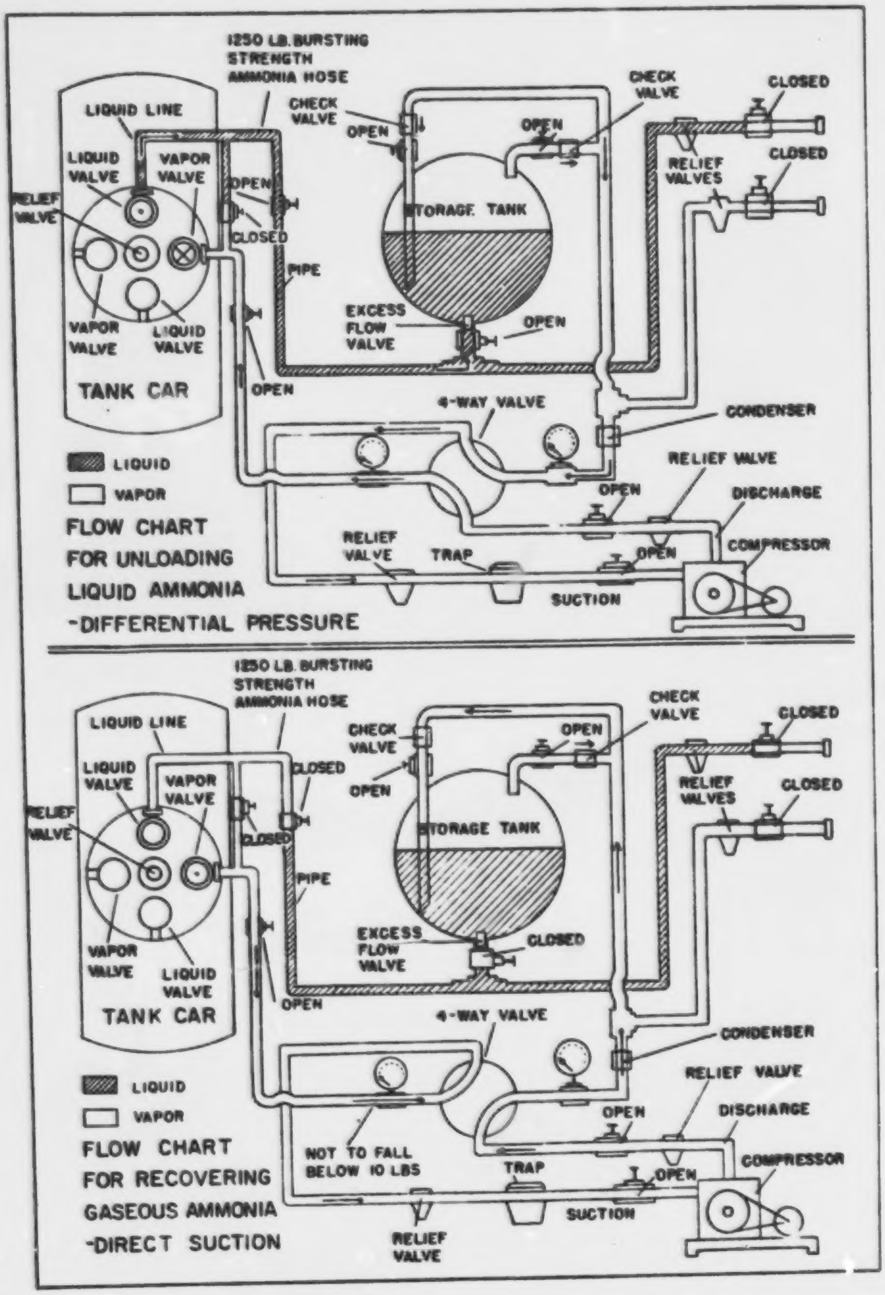
1250 LB. BURSTING STRENGTH AMMONIA HOSE
LIQUID LINE
CHECK VALVE
OPEN
CHECK VALVE
OPEN
CLOSED
LIQUID VALVE
VAPOR VALVE
OPEN
RELIEF VALVES
CLOSED
RELIEF VALVE
CLOSED
STORAGE TANK
PIPE
VAPOR VALVE
LIQUID VALVE
EXCESS FLOW VALVE
OPEN
TANK CAR
OPEN
4-WAY VALVE
CONDENSER
▨ LIQUID
☐ VAPOR
RELIEF VALVE
OPEN
DISCHARGE
FLOW CHART FOR UNLOADING LIQUID AMMONIA -DIFFERENTIAL PRESSURE
RELIEF VALVE
TRAP
OPEN
COMPRESSOR
SUCTION
1250 LB. BURSTING STRENGTH AMMONIA HOSE
LIQUID LINE
CHECK VALVE
OPEN
CHECK VALVE
CLOSED
LIQUID VALVE
VAPOR VALVE
CLOSED
OPEN
RELIEF VALVES
CLOSED
RELIEF VALVE
CLOSED
STORAGE TANK
PIPE
EXCESS FLOW VALVE
CLOSED
VAPOR VALVE
LIQUID VALVE
TANK CAR
OPEN
4-WAY VALVE
CONDENSER
▨ LIQUID
☐ VAPOR
RELIEF VALVE
OPEN
DISCHARGE
FLOW CHART FOR RECOVERING GASEOUS AMMONIA -DIRECT SUCTION
NOT TO FALL BELOW 10 LBS
TRAP
OPEN
COMPRESSOR
SUCTION
RELIEF VALVE

Figure 1. Typical unloading setup using differential pressure. Upper drawing shows arrangement of open and closed valves for differential pressure unloading; lower drawing—valve arrangement for unloading residual vapor by direct suction. Bypass valve between the liquid and vapor lines to the tank car is normally kept closed. It is opened only when pressure on either side of the tank car check valve is to be equalized.

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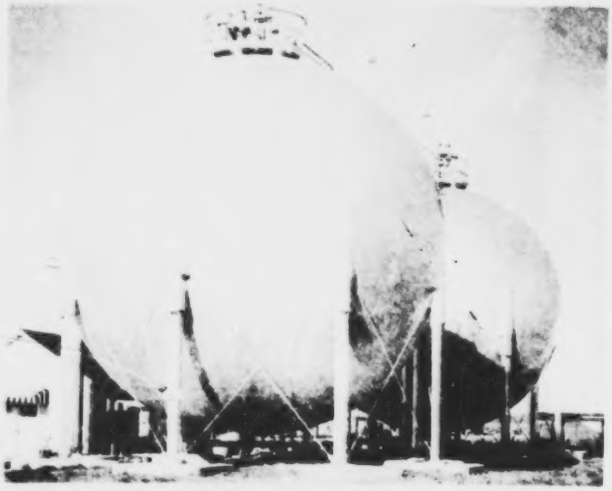

Figure 2. Typical refrigerated storage containers for anhydrous ammonia.

ures listed here apply to all facilities and are recommended safe practices. ICC regulations state the minimum design pressure for tank motor vehicles, and also that the following steps be taken:

a. Attended during loading and unloading operations.
b. That the shell or head thickness be not less than 3/16 of an inch.
c. Only qualified and thoroughly trained personnel should operate the truck and perform the unloading operations.
d. When the truck has been properly spotted the engine ignition should be shut off before connections have been made for unloading. The truck should not be started again until unloading operations are complete, unless it becomes necessary to operate the unloading pump or compressor by power from the truck.
e. The truck parking brakes must be securely set. At least two chock blocks should be provided. These blocks should be placed to prevent the vehicle from moving wherever and whenever it is parked during loading or unloading operations.
f. Personnel should be provided with necessary protective equipment.
g. The storage tank should be gauged prior to unloading.

13. The detailed sequence of connecting the hoses to the plant piping, opening and closing valves, etc., will vary depending on the physical arrangements of the particular plant, its facilities, and whether the transfer is done with a vapor compressor or liquid pump.

14. The attendant should supervise the actual unloading and in the event any difficulty arises, such as a leak, the operation should be halted until the difficulty is corrected or eliminated.

15. If the unloading is done by a vapor compressor, the valving arrangement should be switched at the end of the liquid-transfer operation so the vapor can be recovered from the tank truck to allow the pressure to be reduced to the proper level.

16. When the operation is completed, the unloading valves should be closed and the pump or compressor stopped.

17. The hose connections should then be vented before the hose is disconnected. The operator should stand on the upwind side during the venting operation and disconnect the hose and store it to avoid damage. Then he should remove the chock blocks (Refer to Paragraph 12c).

18. Each tank motor vehicle should be provided with properly attached bumpers or chassis extension arranged to protect the tank, piping, valves, and fittings from damage in the event of a collision. Hoses should have a minimum bursting pressure of 1750 psig.

19. *Containers.* Equipment eventually used for the direct application of anhydrous ammonia consists of (a) a container with a shell or head thickness of 3/16 of an inch that is designed for a working pressure of 250 psig; and (b) flow-regulating equipment, interconnecting piping, and applicator, which may be a separate implement or an attachment for a towing tractor and mounted directly on it.

20. The container is normally small (250 gallons or less) and is equipped with the necessary shutoff valves, excess flow valves, safety relief valve, etc. It must be securely mounted on the applicator implement.

21. The flow regulation is accomplished by the use of one or more multiple outlet ammonia flow regulators, or by the use of a variable stroke, piston-type metering pump. Thus, the rate of application of ammonia to the soil can be accurately controlled.

22. The basic considerations for this application equipment are the same as for the transportation and storage equipment, that is, the components should be suitable for ammonia service and the unit properly maintained. The primary consideration is, of course, that no brass or bronze be used within the system. Chemical safety goggles and gloves should be available and used when and where necessary.

23. *When tank cars* are being unloaded, shipper's instructions should be observed and carried out by fully instructed reliable employees under adequate supervision. They should be connected to permanent plant piping with a 1750 psi bursting strength ammonia hose. The hose should meet all RMA hose standards with a working pressure of 350 psi. Hose assemblies should be hydrostatically tested and capable of withstanding a test pressure of 500 psig at one year intervals. The hose should always be protected with a No. 350 hydrostatic relief valve in line. All connections should be made with high pressure screws or flanged fittings, of black iron or forged steel.

24. The standard ICC regulations governing the unloading of tank cars should be followed whenever ammonia is being unloaded. Before the car is connected, the blue flag (or a light-blue sign 12 by 15 inches with the legend STOP—TANK CAR CONNECTED) should be set out at least 25 feet from the switch end of the car. One sign will be necessary for blind sidings and two for a siding which may be entered from either end. Switches should be

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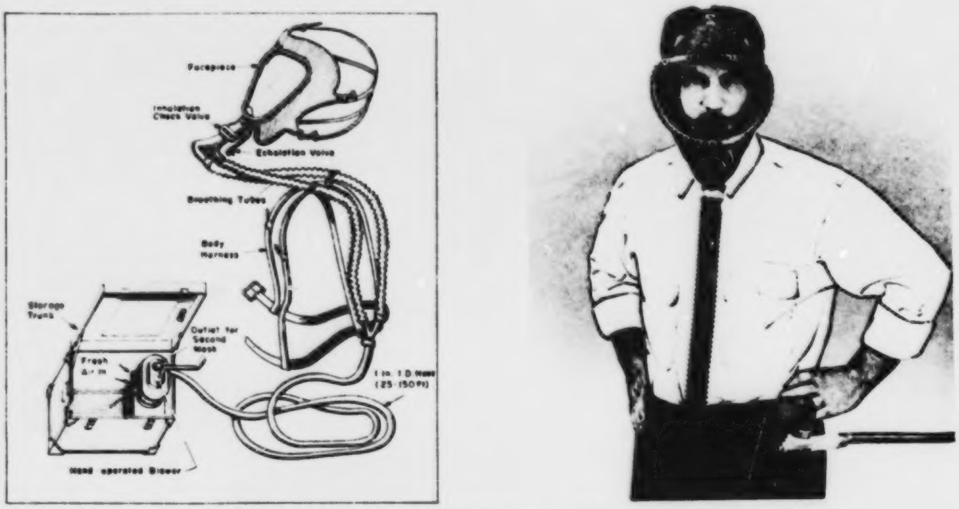

Figure 3. Diagram (left) of hose mask with air supplied by hand-operated blower. Air line hose mask (right).

locked closed. "Derails" may be set out at least one car length from the switch end of the car being unloaded. Hand brakes should be set and the wheels chocked. The car can then be connected after completing these procedures.

25. Anhydrous ammonia is usually unloaded from a tank car by differential pressure (Figure 1). The usual practice is to connect the liquid discharge valve in the car dome directly to the storage container and a vapor valve in the car dome to compressor (275 psig working pressure) taking suction from the storage container. Pressure built up above the liquid in the tank car forces the liquid ammonia into the storage container.

26. Any saturated ammonia vapors which are left in the car after the liquid has been withdrawn, can be partially removed by closing the liquid valves on the car and the container and withdrawing the vapors through the compressor by reversing the 4-way control valve.

Shipping regulations

27. The ever-increasing demand for anhydrous ammonia has dictated development of safe and efficient, large volume transportation facilities. Currently, these transportation facilities include cylinders, tank cars, tank trucks, portable (skid) tanks, barges, and ships.

28. All this transportation equipment is similar to that used for LP-gas, except the valves, fittings, and the like, are made of iron or steel on the equipment for anhydrous ammonia, while brass and bronze fittings are quite commonly used on LP-gas equipment.

29. The requirements for these transportation units moving interstate are specified by the Interstate Commerce Commission (ICC). Any movement of anhydrous ammonia by water (barge or portable tanks on vessels, etc.) is regulated by the U.S. Coast Guard.

Storage

30. *Non-refrigerated storage:* All containers for non-refrigerated bulk storage of ammonia should be built of steel with a minimum working pressure of 250 psi and constructed and tested according to the latest edition of the ASME *Unfired Pressure Vessel* code (and subsequent amendments thereto), or under the rules of the authority having jurisdiction where the tank is installed.

31. Containers should be visually inspected at least once a year. Hydrostatic testing should be 1½ times the working pressure of the tank. Other nondestructive testing may be done as required.

32. All tanks must be equipped with one or more spring-loaded relief valves in the vapor phase of the tank set to relieve at 250 psi. If the valves are mounted on a manifold which allows the changing of the valve without the emptying of the tank in case of valve failure, it will not be necessary to test the valves more than once every 5 years. If internal valves are used, they should be tested every year. (ICC requires every 5 years, but experience has shown that stress, corrosion, and cracking still occur in the springs in a shorter amount of time. Many tanks have leaked at relief valves in less than 5 years.)

33. The discharge from these valves should be vented upward into the atmosphere in such a way as not to contaminate the area near by or endanger workers or others passing by. The discharge pipe should be fitted with rain caps or some other device to prevent the accumulation of moisture. Provisions should be made to drain any condensation which may accumulate in the vent lines.

34. The filling densities for storage containers that are not refrigerated should not exceed the following:

Type of container	*Per cent by weight*	*Per cent by volume*
Above ground uninsulated	56	82
Above ground uninsulated	—	87.5
Above ground insulated	57	83.5
Underground uninsulated	58	85
ICC	Follow ICC regulations	

35. Magnetic, or rotary gauges are preferred to gauge glasses. Where glasses are used they should be protected against accidental breakage by a guard which will confine flying glass if they burst. As a further precaution, the two shut-off valves should be kept closed except when a gauging is made.

36. Bulk storage containers should preferably be located above ground, and rest on firm supports, preferably of concrete.

37. Storage containers should be protected from the direct rays of the sun by a white enamel reflecting paint. Exposed piping should also be protected in the same manner.

38. Ammonia and LP-gas have similar characteristics and the tanks used to handle them are similar. Before tanks can be interchanged, it must be determined that it is possible to safely do so. If so, the following steps should be taken:

a. Openings should be opened satisfactorily.
b. All fittings must be changed to steel.
c. Tanks must be thoroughly purged of NH_3 before going to LP use. Interchange of service should not be attempted unless supervised by qualified personnel.

39. *Refrigerated storage:* Refrigerated storage containers with a design pressure exceeding 15 psig should be constructed in accordance with appropriate sections of the current ASME Code, *Unfired Pressure Vessels* and API Standard 620, *Recommended Rules for Design and Construction of Large, Welded, Low Pressure Storage Tanks,* latest edition. Local ordinances could modify these requirements (Figure 2).

40. At least two compressors should be provided for a refrigerated system, either one of which has sufficient capacity to handle the entire load. An emergency power supply of sufficient capacity to handle the load should be provided unless facilities are available to safely dispose of the vapor while the refrigeration system is not in operation.

41. If refrigerated storage systems and compressor rooms are unattended, they should be equipped with automatic alarms.

42. The filling connections should be fitted with a remote-controlled valve as should all openings except relief valves. Excess flow or backpressure check valves should also be installed in the filling connection.

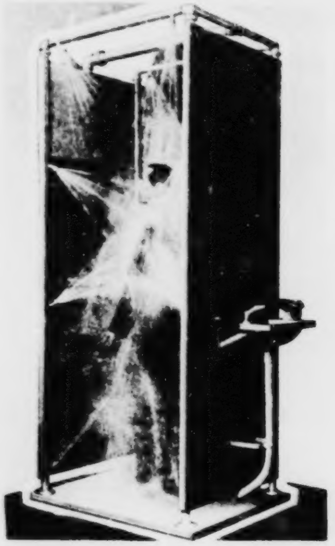

Figure 4. Emergency shower enclosure.

43. There should be at least two safety relief valves on every storage container, each set to open at the design working pressure and to maintain the pressure at not more than 120 per cent of the design working pressure. The discharge should be vented well upward into the air where there will be no contamination problem. Discharge pipes should be fitted with rain caps or some other weather protection to prevent the accumulation of moisture. Provisions should be made to drain the condensate from the safety relief discharge lines.

44. Portable storage containers such as those commonly used in direct application to the soil or to transport ammonia from supply station to the farm, if not under ICC jurisdiction, should be constructed to comply with the latest ASME Code, with a 250 psi working pressure.

45. These storage containers should be securely fastened to the carrying vehicle so that even under unusual strain they will not shift on their mountings. All fittings, valves and gauges should be protected against accidental damage by substantial steel guards. Filler openings should be protected by a backpressure or excess-flow valve. All other openings except those connecting with the safety relief valves should be protected by excess-flow valves.

46. Storage containers with a capacity under 1200 gallons should be protected by a spring loaded safety relief valve set to discharge at 250 psig. Those of greater capacity require two or more spring loaded safety relief valves. The discharge cap of these valves should meet the requirements of ASME Code (Table III).

47. The following equipment should be ready at all times for emergency use:

a. One pair of protective gloves, either plastic or rubber.
b. One pair tight-fitting safety goggles.
c. Container with not less than 5 gallons of clear water.

Over-the-road type transports should have, in addition, full face gas mask with anhydrous ammonia canisters.

48. *Cleaning storage containers:* When storage containers are to be cleaned, a section of the supply piping should be removed. *Blanking flanged unions are not recommended.*

49. Storage tanks should be purged with water and steam. *Petroleum solvents should not be used.*

50. Each workman entering a storage tank should wear respiratory protective equipment (hose mask with a blower or self-contained breathing apparatus). He should also be equipped with a safety harness attached to a lifeline that is tended by a helper similarly equipped and stationed immediately outside the point of entry.

51. *Piping and fittings:* Shutoff valves, relief valves, and pressure reducing valves should be made of extra-heavy black iron or forged steel to withstand a working pressure of 250 psi. Monel or resilient valve seats may be used. Lead seats are satisfactory in some service. Copper or copper bearing fittings or valve seats should not be used.

NOTE: Galvanized pipe should never be used. Welded joints are preferred to threaded joints. Under no circumstances should brazed joints be used, because they deteriorate rapidly.

52. All refrigerated piping should conform to American National Standard B31.5 or latest revision.

53. Where threaded connections must be made, only Schedule 80 pipe should be made. All connections should be made tight, using a pipe joint compound that is resistant to NH_3.

54. Ammonia-type forged steel, raised-face flanges should be used. If flanges are used, they should be at least of the four-bolt type.

55. Wherever there is a possibility that an ammonia line may be closed at both ends while liquid filled, the line should be protected by a hydrostatic relief valve.

56. *Leaks:* Ammonia leaks can be located by moving an open bottle of hydrochloric acid along the ammonia piping. A cloud of white ammonium chloride will be generated near the leak. Also a small amount of sulfur dioxide can be released along the suspected leak. A white fog of ammonium sulfate will be formed. (Burning of sulfur tapers is not recommended.)

57. Leaks around cylinder valve stems can generally be corrected by tightening the packing gland nut which has a lefthand thread. It is particularly important that only the tools recommended by the ammonia supplier be used on cylinders, ton tanks, and tank car valves. The leverage obtainable with longer wrenches may damage the valve and make a leak worse.

58. When leaks at valve stems or connections do not respond to ordinary tightening, the service department of the ammonia supplier should be called at once. Emergency leak kits are unavailable for ammonia similar to those available for chlorine containers.

59. If a serious leak in the container develops and cannot be controlled, the container should be discharged into water. If there is no danger of contaminating an area or endangering employees, the ammonia can be discharged into the atmosphere where it will rapidly dissipate. Water from a hose may be directed upon the leak and a considerable portion of the escaping ammonia absorbed. If possible, the container should be turned so that the leak is uppermost. In this way

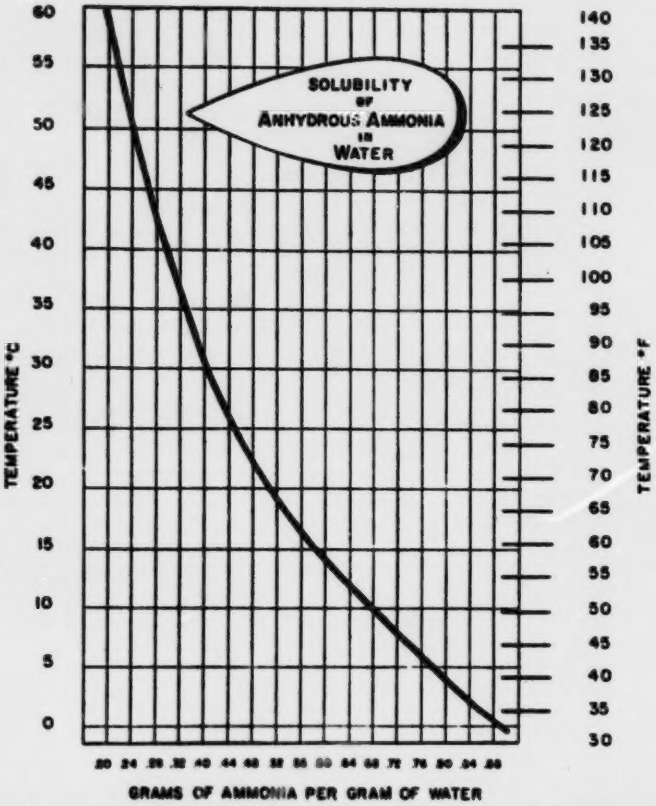

Figure 5. Chart shows the relationship between weight of ammonia in hundredths of grams per gram of water to the temperature. Since the relationship shown here is that of unit weight per unit weight the values shown are the same for pounds of ammonia per hundred pounds of water.

TABLE III

Relief valve discharge rate for containers of circular cross sections

Container Size*	Discharge Rate**	Size	Rate	Size	Rate
10	419	160	6340	400	10300
15	634	180	7050	420	10600
20	842	200	7345	440	10890
30	1248	220	7695	460	11190
40	1649	240	7935	480	11500
50	2055	260	8240	500	11775
60	2450	280	8530	520	12075
70	2845	300	8825	540	12370
80	3225	320	9125	560	12665
100	4040	340	9420	580	12965
120	4820	360	9720	600	13250
140	5590	380	10000	620	13550

*This figure represents product of outside diameter and length (feet) for cylindrical containers or the square of the outside diameter (feet) for spherical containers.

**Discharge rate given in cubic feet of air per minute measured at 16 C (60 F) and one atmosphere pressure (14.696 psig).

only gas will be discharged and the water will have a better chance of absorbing the ammonia.

60. Water which has been used to absorb ammonia should not be discharged into municipal or confined sewers.

61. Under no condition should liquid ammonia be neutralized with an acid. This procedure would generate a great amount of heat and increase the volume of liberated gaseous ammonia.

62. Whenever a leak develops in an ammonia line or ammonia container, all personnel in the immediate vicinity should be evacuated, upwind of the leak. Only trained personnel with proper protective equipment should be allowed to approach an ammonia leak.

Personal protective equipment

63. Men who regularly work with ammonia and are therefore vulnerable to exposure to either the liquid or the gas should be provided with rubber or neoprene gloves, and tight-fitting safety goggles. They should wear cotton clothing and underwear. A ventilated safety goggle gives protection against direct splashes of ammonia in the eyes. A small amount of contamination within the atmosphere affects the nose before eye injury would occur from vapor and indicates a need for full-face mask. Vented safety goggles do not fog up and are much more comfortable to wear.

64. Gas masks (approved for ammonia by the U. S. Bureau of Mines) with a full facepiece and green ammonia canisters (C) or a red universal (N) should be available in case of emergency (Figure 3). Under conditions of extreme exertion these gas masks will provide respiratory protection for only about five minutes in concentrations of 3 per cent, or fifteen minutes in a concentration of 1 per cent, if there is no deficiency of atmospheric oxygen. A gradually increasing odor of ammonia in the inspired air will warn that the canister is becoming exhausted.

65. The points in an ammonia system where leaks may develop can be anticipated and gas masks located accordingly. Respiratory protection devices should be located just outside areas of possible contamination so workmen can reach respiratory protective equipment.

66. No one can remain in an atmosphere with a concentration higher than 1.5 or 2 per cent of ammonia for more than 15 minutes without developing severe skin burns and blisters. For this reason respiratory protection alone is not enough.

67. Maintenance men and others who must work for more than a few minutes in concentrations higher than 1.5 or 2 per cent should be equipped with a well-ventilated, one-piece rubber or neoprene suit, impervious to gas and sealed at the ankles, wrists, and around the face.

68. The suit plus the full-facepiece gas mask will give complete protection for the life of the canister in atmospheres up to 3 per cent of ammonia. However, none of this equipment will protect against the freezing effects of evaporating ammonia.

69. Supplied air respirators, or oxygen breathing apparatus should be worn, along with the suits mentioned above, in unknown concentrations or in connections of ammonia above 3 per cent. Their useful life is determined by the size of the supply unit. A hose mask with blower is useful in high or unknown concentrations. Its usefulness is limited by the length (150 foot maximum) of the hose which connects the mask with the blower unit. The blower unit must be located to supply uncontaminated air.

70. For prolonged work in contaminated atmospheres a hose mask with blower will probably be most comfortable to wear. The resistance to normal breathing of this equipment is probably much less than with other types.

71. Workers should be thoroughly trained in the use of personal protective equipment and should automatically report any that is defective. This equipment must be inspected at regular intervals and maintained in first class condition.

72. Atmospheric ammonia will dissolve readily in perspiration. Therefore, persons who work long periods in contaminated areas can expect some irritation due to absorbed ammonia at the crotch, armpits, feet, and wherever clothing is tight. Petroleum jelly spread at these places may provide some protection.

Fire and explosion hazards

73. The gas, if mixed with air in the proper proportion, will burn. The flammable limits of this mixture is 16 to 25 per cent by volume in air at atmospheric pressure. The presence of oil or other combustible materials will increase the fire hazard.

74. In the presence of iron the ammonia-air mixture will ignite at 1203.8 F (651 C). When iron is not present the ignition temperature is much higher: above 1562 F (850 C). For instance, oil vapor, introduced through compressors will increase the fire hazard somewhat. Ammonia-air mixtures are difficult to ignite. They require both a large and an intense source of ignition and a relatively high concentration of the gas. However, there have been several severe flash fires and a few very bad explosions at breaks in compressors, receivers, and condensers. Repairs on ammonia containers should only be performed by qualified welders, and all repair work must be done to conform with requirements given in the applicable ASME Code under which the tank was constructed. Any welding or cutting on a tank which has contained ammonia, must not be done without first thoroughly purging the tank of all ammonia vapors. The heat of the welding or cutting torch could cause an explosion.

75. Most common metals are not affected by anhydrous ammonia; however, when mixed with very little water or water vapor, both gaseous and liquid ammonia will attack vigorously, copper, silver, zinc, and their alloys. It will combine readily with either silver oxide or mercury to form explosive fulminating compounds. Iron or steel will not react readily with either dry or moist ammonia.

76. Ammonia will dissolve readily in water to form ammonium hydroxide. At 32 F (0 C), one volume of water will dissolve 1176 volumes of gaseous ammonia, or 100 lb of water will dissolve 89.5 lb of ammonia. At 68 F (20 C) one volume of water will dissolve 700 vol of ammonia (53.1 lb am-

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monia per 100 lb water) (Figure 5).

Electrical equipment

77. Electrical equipment in open air installations need not be explosion-proof. When installed inside a building, all electrical installations should be explosion-proof. Grounding of the tanks is no longer required.

Symptoms of poisoning

78. The conventional symptoms of developing pulmonary edema should be observed regularly. Anyone exposed to ammonia who breathes in short, rapid shallow breaths should be immobilized. In most cases twenty-four hour bed rest, under the observation of a physician, will be necessary before it can be determined that the victim is out of danger.

79. Anyone who accidentally has been exposed to high or unknown concentrations of ammonia and who has ammoniacal breath, tightness of the chest, bloodshot eyes with swollen lids, and a cough which may discharge bloody mucous is seriously ill. Medical assistance should be summoned immediately. Such a person should be immobilized at once, his eyes washed, and oxygen administered by a physician.

80. If it is necessary to move the patient he should be carried on a litter or an improvised stretcher. Any sort of movement on his part will aggravate the developing edema and may result in death.

First aid

81. Ammonia which has come in contact with the skin should be removed as soon as possible. Contaminated clothing should be removed and the affected skin areas flooded with large amounts of water for at least 15 minutes. The patient should see a physician as soon as possible. Extreme care should be exercised in removing clothing which has become frozen.

CAUTION: Forcible removal of frozen clothing may tear the skin badly. Therefore, proper thawing is a must.

82. Safety showers should be conveniently located for people who are vulnerable to exposure of ammonia, but they should not be located where an ammonia leak may make them unusable. Showers should operate by pressure on valve arm or platform and should supply a gentle flood of water at a rate of about 30 gallons per minute (Figure 4). High-pressure needle-spray showers may irritate a severe ammonia burn.

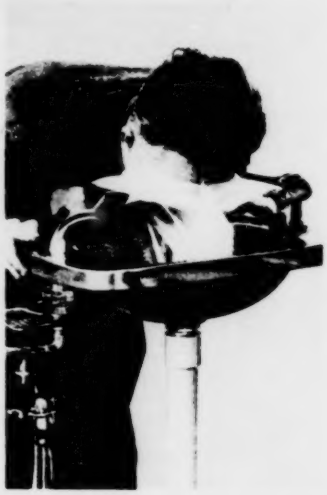

Figure 6. Eye-wash fountains should be located wherever there is a danger of ammonia entering the eyes.

83. Ammonia must be removed from the eyes immediately. Treadle- or brow-operated eye wash fountains or non-refrigerated bubblers should be available wherever there is the danger of ammonia entering the eyes (Figure 6). The eye should be forced open, with the lids turned back and flooded for 15 or 20 minutes. If this is not done a serious loss of vision may result.

84. After the eyes have been flooded for 15 or 20 minutes the patient should be taken at once to a physician or hospital. No oil or other non-water-soluble preparation should be placed into the eyes.

85. Anyone overcome by an ammonia atmosphere should be removed to fresh air at once. He should be kept warm; artificial respiration (back-pressure, armlift, or mouth-to-mouth resuscitation) should be started at once if breathing is labored or has stopped. Oxygen should be administered as soon as possible by a physician.

86. Symptoms of developing respiratory difficulty are hard to spot. Anyone who has been under a concentration of ammonia for over half an hour without respiratory protection should be assumed to be in danger and should be seen by a physician at once. If a man encounters strong concentrations he should remove himself from the vicinity of the exposure immediately.

87. Definite first aid instruction should be given to all men who work with ammonia. This should be done by approved instructors. He should also determine what procedures should be done by employees until medical assistance is obtained.

Treatment of burns

88. When the ammonia has been removed from the skin, the burned area should be treated in the same fashion as any chemical burn.

Toxicity

89. Ammonia is not a poison. It has no cumulative toxic effect, as lead or mercury have. However, it has a powerful corrosive action when it makes contact with skin tissue. Exposure to atmospheric concentrations of ammonia above 5000 parts ammonia per million parts of air (0.5 per cent by volume) will produce death by suffocation within minutes. Atmospheric ammonia in concentrations above 2000 ppm (0.2 per cent) will burn and blister the skin after a few seconds of exposure.

90. Liquid ammonia in contact with the skin will produce severe burns not only because of its strong corrosive action, but also through the freezing effect produced by its rapid evaporation. Dehydration is a serious effect.

91. Concentrations above 700 ppm (0.07 per cent) will cause severe eye irritation, hemorrhages, swollen eyelids, and if not treated immediately may lead to partial or total loss of eyesight. Prolonged exposure to atmospheric ammonia above this concentration (700 ppm) may produce severe scarring of the exposed eye tissue, especially the cornea.

92. The mucous tissue lining the mouth, throat, nose, and lungs is particularly sensitive to atmospheric ammonia. Ammonia attacks the

mucous tissue of the lungs and upper respiratory tract quite violently.

93. Exposure to concentrations above 1700 ppm (0.17 per cent) may produce serious lung edema (a copious discharge of blood serum into the alveolar spaces of the lungs) and unless properly treated, death will result.

Threshold limit values

94. The threshold limit value (TLV), as established by the American Conference of Governmental Industrial Hygienists, represents a concentration to which workers may be exposed repeatedly without adverse effect. This concentration is a time-weighted value averaged over a normal workday. For anhydrous ammonia, the threshold limit value is 50 ppm. Since ammonia serves as its own warning agent, a person will not remain in concentrations which are hazardous.

95. There are several reliable analytic schemes for checking the atmospheric concentration of ammonia. Ten parts of ammonia per million of air will affect moist commercial litmus paper in about 6.5 seconds and moist commercial phenolphthalein paper in about five seconds. One-hundred ppm of ammonia will affect moist phenolphthalein paper as soon as it is exposed and moist litmus paper in about one second.

96. Contaminated air may be collected in 0.1N sulphuric acid and titrated against 0.1N sodium hydroxide using methyl red as the indicator. A very accurate determination should be made. The Folin-Nessler reaction will give accurate determinations even in low concentrations.

ACKNOWLEDGMENT

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- "Anhydrous Ammonia and Aqua-Ammonia Chemical Safety Chart," *Chemical Safety Chart No. 3*, Bureau of Labor Standards, 1952.
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An Alphabetical Index of all Industrial Safety Data Sheets (Stock No. 123.09) is available from the Council on request.

The information and recommendations contained in this publication have been compiled from sources believed to be reliable and to represent the best current opinion on the subject. No warranty, guarantee, or representation is made by the National Safety Council as to the absolute correctness or sufficiency of any representation contained in this and other publications, and the National Safety Council assumes no responsibility in connection therewith, nor can it be assumed that all acceptable safety measures are contained in this (and other publications), or that other or additional measures may not be required under particular or exceptional conditions or circumstances.

E.3.3 RSMA Safety Data Sheets

Safety data sheets that have recently been issued by the Railway Systems and Management Association, 181 Lake Shore Drive, Chicago, Illinois Zip Code 60611, assign a priority number to each commodity. The carrier lists cargo items onto a Priority-Risk Worksheet. A blank worksheet with instructions is shown as Exhibit E-8, and safety data sheets for Anhydrous Ammonia, Phosgene, and Vinyl Chloride are shown as Exhibits E-9 through E-11, respectively.

PRIORITY-RISK WORKSHEET

The Priority-Risk Worksheet gives the man in control of an accident scene the initial organization needed when faced with an emergency involving more than one hazardous commodity. With this and the other data sources in the Handling Guide, he can logically direct the most effective, safe and expeditious plan for handling the situation.

PRIORITY-RISK WORKSHEET INSTRUCTIONS

Highest number indicates greatest hazard.

F=serious FIRE hazard

H=serious HEALTH hazard

1. Find commodity in Data Form section, noting the rating number in the upper left corner of the page.
2. Enter name of commodity on work sheet next to proper rating number.
3. Enter actions shown for handling commodity on work sheet.
4. Check for conflicting instructions between commodities.
5. Handle the highest rated commodity first, UNLESS an immediate greater hazard from a lower rated commodity exists.

Exhibit E-8. Priority-Risk Worksheet

PRIORITY-RISK WORKSHEET

For use in organizing order of actions in transportation emergencies.

RATING	COMMODITY	A[illegible]N
24FH		
23FH		
22FH		
21FH		
20F		
19F		
18F		
17F		
16F		
15F		
14H		
13H		
12H		
11H		
10H		
09H		
08		
07		
06		
05		
04		
03		
02		
01		
00		

Exhibit E-8 (continued)

11H .... PRIORITY-RISK RATING

When not burning, a major health threat, but gas lighter than air, so disperses. Although gas, fairly hard to ignite; once ignited, a major fire danger.

CODE **0451**

COMMODITY............ AMMONIA (ANHYDROUS)

SYNONYMS:
Anhydrous Ammonia

---

1. CLASSIFICATION—RISK: N. G.

- Non-flammable compressed gas
- GREEN label required.
- **Just barely outside criteria for Flammable Compressed gas, Ammonia has been afire in numerous accidents.**

2. DEGREE OF—RISK: W-3, 1

Severity of risk from exposure to material as normally shipped. Mixture upon spillage and local conditions may alter this rating.

- Warning-moderate, intermediate, harmful toxic material—can injure through breathing or touching.
- Also flammable material.
- **Strong irritant to eyes, skin, respiratory tract.**
- **Causes severe burns in liquid form.**
- **Can blind if exposed to ½% by volume in air for ½ hour.**

3. PRECAUTIONS—RISK: 3, 1, 2

To minimize hazards, take precaution indicated:

- Avoid breathing mists, gases.
- Keep away from heat, sparks, open flames.
- Avoid contacting skin, eyes, clothing.

LEAKS

- **Sharp penetrating odor in area indicates leak; clear area.**
- **Gas leaks found by dipping rag on stick in hydrochloric (muriatic) acid; when placed near leak by protected person, white cloud will form.**
- **Do not approach or contact liquid spills; form dikes to contain them.**
- **Spray large leaks directly with large volumes of water.**
- **Isolate leaking cylinders or tanks from fire or flammable or hazardous materials, especially oil, liquid oxygen, calcium, acids, chlorine, bromine or hypochlorites of sodium or calcium.**

EYES

- **Gas-tight chemical goggles, running water to flush eyes.**
- **Ammonia has affinity for moisture, so critical level can be reached in unprotected eyes before other symptoms show.**

BREATHING

- **Self-contained breathing apparatus where gas causes violent coughing.**
- **Chemical cartridge respirator where gas only irritating.**
  Filter-type respirator is ineffective.

BODY

- **Rubber or protective gloves, rubber apron and/or cotton clothes, long sleeves and collar buttoned.**
- **Shower and change clothes if exposed directly, or if perspiration present, as it absorbs Ammonia.**

4. HAZARD TO—LIFE: 3

Type of injury from material beyond heat of fire or force of explosion:

- Short exposure could seriously injure, even if promptly treated.
- **Although contact with liquid can cause serious burns, main threat is inhalation of gas, which can lead to death.**

5. FIRST-AID—LIFE: C

First-aid instructions in case of contact or exposure:

- Immediately flush skin with plenty of water. Flush eyes with water for at least 15 minutes. Get prompt medical attention.

BODY

- **Use no salves or ointments on burns for 24 hours.**

BREATHING

- **If violent coughing occurs, remove from area.**

Exhibit E-9. RSMA Safety Data Sheet on Anhydrous Ammonia

- **If brief exposure, normally no further aid required.**
- **If prolonged exposure, administer oxygen.**

SUGGESTIONS TO PHYSICIANS

EYES

- **Wash with Boric Acid solution (1 part with 29 parts water).**
- **2-3 drops ½% pontocaine solution or other aqueous topical anesthetic.**

INHALATION

- **If prolonged moderate exposure, 100% oxygen at atmospheric pressure, not to exceed one hour continuous. Best to use face mask with non-breathing type reservoir bag. Reinstitute as conditions indicate.**
- **If severe exposure, use oxygen under exhalation pressure not to exceed 4 cm (about 1 9/16") water, for ½ hour periods out of each hour, until symptoms subside or other clinical indications for interruption appear.**
- **Caution: oxygen under pressure may be inadvisable in presence of pending or existing cardiovascular failure.**
- **Observe for laryngeal spasm; perform tracheotomy if needed.**

6. DANGER—FIRE: 1

Conditions under which material might ignite:

- Must be preheated before ignition can occur.
- **As liquid, may flow to source of fire, increasing fire risk.**
- **As gas, is lighter than air; will disperse up unless wind blows it to fire source.**

7. CONTROL—FIRE: E

The amount, rate and method of using the Fire Extinguishing Agent in relation to the size and type of fire must be carefully considered.

- Stop flow of gas.
- **If leak cannot be stopped, let burn; cool container with water to prevent further failure.**
- **If not on fire, dilute liquid with large amounts of water; this keeps concentration of resultant gas down.**
- **Use water spray in air to remove gas from air and to keep temperature below ignition.**
- **Will react with substances cited in 3 above.**

8. STABILITY—AREA: 0

Reaction of material alone or with water. Does not include reaction with other materials:

- Normally stable, even under exposure to fire.

9. CLEAN-UP—AREA: —

Toxicity of materials to be considered for clean-up and disposal. Index: Amount to produce death when swallowed by an average (150 lb.) man:

- Information not available.
- **Gas; oral toxicity not apply.**
- **However, it is highly toxic and irritating; can cause severe burns or death.**
- **In open area where safe, let disperse, being lighter than air.**
- **If above not permitted or safe, use water spray to remove gas from air.**
- **If permitted, dilute liquid waste with large amount water & wash into sewer.**
- **If sewer disposal not possible, contain waste by dikes, dilute with large amount water. Later pump into salvage tank or neutralize with suitable acid under supervision.**

0. GENERAL PROPERTIES

AS SHIPPED—Liquified gas under pressure.

COLOR—Colorless.

FLAMMABILITY—Moderate, limits 16-25% by volume in air.

AUTOIGNITION—1,204°F.

CORROSIVITY—Corrosive to body tissue, copper & copper alloys & galvanized surfaces.

ODOR—Intensely pungent.

VAPOR DENSITY—0.597 X as heavy as air.

FORMULA—NH_3

USE—Very important in production of fertilizer. Also in manufacture of synthetic fibers, explosives and nitric acid, and as a refrigerant. Used in many processes in chemical industry.

Exhibit E-9 (continued)

19H .... PRIORITY-RISK RATING

Ranked at top of group with high health and moderate to low fire risk because non-flammable poisonous gas that is heavier than air and relatively easy to breath in fatal amounts. Shipped in heavy cylinders or tank cars without safety devices (preventing release of gas until complete tank failure), so release of gas tends to be all-or-nothing situation. If leaking, moves to near top of PRIORITY-RISK Table, indicated by appended "H."

CODE **7003**

COMMODITY .... PHOSGENE

SYNONYMS:

Carbon Oxychloride; Carbonyl Chloride; Chloride, Carbonyl; Chloride, Chloroformyl; Chlorformyl Chloride; Choking Gas; Diphosgene; D-Stoff; Gas, Choking; Oxychloride, Carbon

---

1. CLASSIFICATION—RISK: P.A.

- Poison gas, Class A.
- POISON-GAS label required.

2. DEGREE OF—RISK: D-3

Severity of risk from exposure to material as normally shipped. Mixture upon spillage and local conditions may alter this rating.

- Danger—Serious, severe, extremely hazardous toxic material—can injure through breathing or touching.
- **Breathing is main risk, potentially fatal.**

3. PRECAUTIONS—RISK: 3, 2, 5

To minimize hazards, take precaution indicated:

- Avoid breathing mists, gases.
- Avoid contacting skin, eyes, clothing.
- Minimize handling until safety precautions are completely understood.

LEAKS

- **If leak suspected, clear immediate area, especially downwind or downhill.**
- **Gas heavier than air; collects in low areas.**
- **Find leak by tying rag soaked in ammonia water on end of stick; protected person holds rag near suspected leak. White cloud forms if Phosgene leaking.**
- **If cannot stop leak, isolate and direct water spray at leaking gas, away from hole.**
- **Personnel should be upwind, uphill and in breathing apparatus. If possible, place leak under water.**
- **If odor detected or leak suspected, potentially exposed persons must be treated as soon as possible as in Section 5 below.**

BREATHING

- **Self-contained breathing apparatus.**

4. HAZARD TO—LIFE: 4

Type injury from material beyond heat of fire or force of explosion:

- Brief exposure could cause death or permanent injury, even if treated promptly.
- **Gas easy to inhale, has non-offensive odor like new-mown hay.**
- **Can desensitize sense of smell, making it harder to detect.**
- **Effects may be delayed several minutes to 24-72 hours, depending on exposure.**

5. FIRST-AID—LIFE: A

First-aid instructions in case of contact or exposure:

- Carry victim to fresh air. Have him lie down. Remove contaminated clothing, but keep him warm. Start first-aid procedures. Call physician.

GENERAL

- **Remove from area. Rescue worker must be protected.**
- **Do not let exposed persons walk; maintain absolute rest.**

BREATHING

- **If breathing stopped, give artificial respiration. Do no use mouth to mouth resuscitation. If breathing, give oxygen: Fire Department likely to have oxygen.**

EYES

- **Flush with large amount running water for 15 minutes.**

BODY

- **Place under shower, remove clothes under shower.**

Exhibit E-10. RSMA Safety Data Sheet on Phosgene

NOTE

- **If person with eye or body exposure also breathed gas, do not delay oxygen treatment.**

SUGGESTIONS TO PHYSICIANS

SYMPTOMS

- **May begin anytime within 72 hours, include burning sensation in throat, tightness in chest, feeling of oppression, dyspnea and cyanosis, with rapid progression to severe pulmonary edema and death from circulatory and/or respiratory failure.**
  Caused by hydrolyzing of gas with moisture in lungs, forming hydrochloric acid, with resultant pulmonary edema.

SEE MEDICAL SUPPORTIVE PROCEDURES for procedure on treating PULMONARY EDEMA.

TISSUE RESPONSE

- **To reduce tissue response to injury, administer cortisone acetate (1 mg/kg orally 1-3 times daily) or other steroid.**

PROGNOSIS

- **Complete recovery has resulted when patient survived first 48 hours.**

6. DANGER—FIRE: 0

Conditions under which material might ignite:

- Will not burn.

7. CONTROL—FIRE: E

The amount, rate and method of using the Fire Extinguishing Agent in relation to the size and type of fire must be carefully considered.

- Stop flow of gas.
- **This is for life-hazard reasons; it does not burn or support combustion.**

8. STABILITY—AREA: 0

Reaction of material alone or with water. Does not include reaction with other materials:

- Normally stable, even under exposure to fire.

9. CLEAN-UP—AREA: —

Toxicity of materials to be considered for clean-up and disposal.
Index: Amount to produce death when swallowed by an average (150 lb.) man:

- Information not available.
- **Gas; oral toxicity not apply.**
- **If leaking, clear area as in 3 above; if safe, let gas dissipate, or use water spray in air to absorb gas.**
- **Workers must have self-contained breathing apparatus.**
- **Trained protected personnel should determine safety of area before re-entry by unprotected personnel.**
- **Waste from spraying leak with water should be diked. Neutralize with soda ash or lime or available alkaline material, if removal by pumping into salvage tanks not feasible.**
- **If permitted, neutralized liquid waste may be disposed in sewers or drainage ditches, if highly diluted.**
- **Do not allow liquid waste on cultivated land.**

0. GENERAL PROPERTIES

AS SHIPPED—Liquified gas under pressure.

COLOR—Colorless gas, colorless to light yellow liquid.

FLAMMABILITY—Not

CORROSIVITY—Not, until exposed to moisture, forming highly corrosive hydrochloric acid.

ODOR—Sweet, like new-mown hay (little); Sharp, pungent (lot).

VAPOR DENSITY—3.4 X heavier than air.

FORMULA—$COCl_2$

USE—Formerly as a war gas. Now used in preparation of many organic chemicals; examples are urea (used in fertilizers), poly-carbonates (new plastics) and urethane foam.

Exhibit E-10 (continued)

25F .... PRIORITY-RISK RATING

Extreme fire threat; highly flammable gas, heavier than air.

Health risk minor; mildly anesthetic.

CODE **9206**

COMMODITY .... VINYL CHLORIDE

SYNONYMS:
Chloride, Vinyl; Chloroethylene; Chloroethene

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1. CLASSIFICATION—RISK: F.L.

- Flammable liquid.
- RED label required.

2. DEGREE OF—RISK: D-1, 3

- Danger—serious, severe, extremely hazardous flammable material.
- Also toxic material—can injure through breathing or touching.
- **Will slowly anesthetize person if enough breathed.**
- **Can freeze body tissue if held in contact by clothing.**

3. PRECAUTIONS—RISK: 1, 3

To minimize hazards, take precaution indicated:

- Keep away from heat, sparks, open flames.
- Avoid breathing mists, gases.

LEAKS

- **Use flammable gas indicator. If not available, detect by odor (sweet smelling gas) or presence of frosting where leak occurs.**
- **Make repairs to stop leak if possible; take care not to cause sparks with tools.**
- **If leaking and not on fire, turn off all ignition sources in area, especially downwind and downhill.**
- **If fire in area, isolate and cool by hosing container with water.**

EYES

- **Where exposure is great, gas-tight chemical goggles, running water available to flush eyes.**

BREATHING

- **Self-contained breathing apparatus.**

SKIN

- **Do not contact liquid; can cause freeze burns, especially if held to skin by clothing.**

4. HAZARD TO—LIFE: 2

Type injury from material beyond heat of fire or force of explosion.

- Intense or prolonged exposure could incapacitate, unless promptly treated.
- **Breathing can anesthetize.**
- **Liquid can cause freeze burns.**

5. FIRST-AID—LIFE: A

First-aid instructions in case of contact or exposure:

- Carry victim to fresh air. Have him lie down. Remove contaminated clothing, but keep him warm. Start first-aid procedures. Call physician.
- **If deep anesthesia occurs, lay person down with head lowered slightly. Call physician.**
- **If breathing stopped, give artificial respiration, then oxygen if needed.**

EYES

- **Flush with large amount running water for 15 minutes. If eye damaged, continue for additional 15 minutes. Call physician.**

SKIN

- **Remove clothing, wash area with large amount running water and soap.
Cover areas that were frozen with sterile gauze or clean towel. Call physician.**

SUGGESTIONS TO PHYSICIANS

SYMPTOMS

- **Slowly produces drowsiness, blurring of vision, staggering walk, numbness or tingling in hands and/or feet.**

INHALATION

- **Oxygen if needed.**

6. DANGER—FIRE: 4

Conditions under which material might ignite:

Exhibit E-11. RSMA Safety Data Sheet on Vinyl Chloride

- At normal temperatures and pressures will rapidly vaporize and burn easily.
- **Extreme danger, since both a highly flammable gas and heavier than air.**

7. CONTROL—FIRE: E

The amount, rate and method of using the Fire Extinguishing Agent in relation to the size and type of fire must be carefully considered.

- Stop flow of gas.
- **Use carbon dioxide, dry chemical type or water spray to put out fire only if leak can then be stopped.**
- **If leak cannot be stopped, let fire burn out, cooling container with water to prevent further failure.**

8. STABILITY—AREA: 1

Reaction of material alone or with water. Does not include reaction with other materials:

- Normally stable, except at elevated temperatures and pressures.
- **Rating based on polymerizing in air, oxygen, sunlight or heat, with evolution of heat; but usually inhibited to prevent this. Not reactive with water.**

9. CLEAN-UP—AREA: —

Toxicity of material to be considered for clean-up and disposal.
Index: Amount to produce death when swallowed by an average (150-lb.) man:

- Information not available.
- **Gas; oral toxicity not apply.**

0. GENERAL PROPERTIES

AS SHIPPED—Liquified gas under pressure.

COLOR—Colorless or water white.

FLAMMABILITY—High, limits 4-22% by volume in air.

AUTOIGNITION—882°F.

CORROSIVITY—Not at normal temperatures when dry.

ODOR—Sweet smelling gas.

VAPOR DENSITY—2.15 X heavier than air.

FORMULA—CH_2CHC1.

USE—Widely used in plastics industry—polyvinyl chloride (PVC) is an example. Also as a refrigerant and in organic syntheses.

Exhibit E-11 (continued)

APPENDIX F

OTHER USEFUL DOCUMENTS
(See Also: Appendix C)

1. Simons, J. H., (Ed.) Fluorine Chemistry, Volume 1. Academic Press, New York, 1950.

2. Schmidt, H. W., Fluorine and Fluorine-Oxygen Mistures in Rocket Systems. National Aeronautics and Space Administration No. SP-3037, U. S. Government Printing Office, Washington, D. C. 1967.

3. Stokinger, H. E., (Ed.) Beryllium: Its Industrial Hygiene Aspects. Academic Press, New York, 1966.

4. Bidstrup, P. L., Toxicity of Mercury and Its Compounds. American Elsevier Publishing Company, New York, 1964.

5. Community Air Quality Guide Series. American Industrial Hygiene Association, 25711 Southfield Road, Southfield, Michigan, 48075.

6. Hygienic Guide Series. American Industrial Hygiene Association, 25711 Southfield Road, Southfield, Michigan, 48075.

7. Henderson, Y. and Haggard, H. W., Noxious Gases and the Principles of Respiration Influencing their Action. ACS Monograph Series No. 35, Reinhold Publishing Corp., New York, N.Y., Second Edition, 1943.

8. Dawson, G. W., Shuckrow, A. J. and Swift, W. H., Control of Spillage of Hazardous Polluting Substances. Battelle Memorial Institute Pacific Northwest Laboratories report for the Federal Water Quality Administration, Department of the Interior; Program No. 1509, Contract No. 14-12-866, November 1, 1970. U. S. Government Printing Office.

9. Case Histories of Accidents in the Chemical Industry. Manufacturing Chemists' Association, Inc., Washington, D. C. 20009.

   Volume One, 1962, Case Nos. 001-596
   Volume Two, 1966, Case Nos. 597-1097
   Volume Three, 1970, Case Nos. 1098-1623

10. Abstract of Proceedings, Hazardous Polluting Substances Symposium, 14-16 September, 1970, Jung Hotel, New Orleans, La.; Department of Transportation, U. S. Coast Guard. National Technical Information Service, Springfield, Va. 22151.

    (Include Annexes)

11. Katz, D. L. (Chairman), A Study of Transportation of Hazardous Materials. Report to the Office of Hazardous

Materials of the U. S. Department of Transportation, Contract No. DOT-OS-A9-106 with Group of Ninety Persons Assembled at Airlie House, Warrenton, Va., May 7-9, 1969. National Academy of Science-National Research Council, Washington, D. C.

12. Goodier, J. L., Stevens, J. I., Margolin, S. V., Keary, W. V., and McMahan, J. R., Spill Prevention Techniques for Hazardous Polluting Substances. Report by Arthur D. Little, Inc., Cambridge, Mass., to Environmental Protection Agency, Water Quality Office, Under Contract 14-12-927, February 1971.

13. McCloud, W. H. (Chairman), Los Angeles County and Cities Disaster Relief Manual. Disaster and Civil Defense Commission August 1, 1969.

14. Hazardous Material Transportation Regulations at the Port of New York Authority Tunnel and Bridge Facilities, effective May 15, 1969.

15. Safety in Air and Ammonia Plants. Vols. 2 (August 1960), 3 (June 1961), 6 (September 1964), 7 (August 1965), 8 (September 1966), 9 (November 1967), 10 (March 1968) available. American Institute of Chemical Engineers, New York, N. Y. 10017.

16. Loss Prevention. Volume 1, February 1967; Volume 2, February 1968; American Institute of Chemical Engineers, New York, N. Y. 10017.

17. Smith, T. C., (Chairman), CIMA Manual. Channel Industries Mutual Aid, Houston-Harris County, Texas, September 1961 (Reprint April 1969).

18. Mutual Aid Program, Kanawha Valley Industrial Emergency Planning Council; Organization and Responsibilities, December 1, 1967.

19. Mutual Aid Program, Kanawha Valley Industrial Emergency Planning Council; Material Assistance Manual, November 1, 1959.

20. Emergency Procedures, Pesticide Spills and Fires. California Department of Agriculture, Sacramento, California 95814.

21. Standard Operating Procedures, Major Oil or Chemical Spill, State of California Disaster Office, SOP-8, revised November 1969.

22. National Academy of Sciences - National Research Council. Evaluation of the Hazard of Bulk Water Transportation of Industrial Chemicals - A Tentative Guide. NAS-NRC Publication No. 1465, Revised, 1970.

23. California Oil Spill Disaster Contingency Plan. State of California Office of Emergency Services, Sacramento, California, June 17, 1969.

24. National Oil and Hazardous Materials Pollution Contingency Plan. Council on Environmental Quality, June 1970.

25. Accidents of Large Motor Carriers of Property. U. S. Department of Transportation, Bureau of Motor Carrier Safety: 1967 Data published December 1968, 1968 published December 1969, 1969 Data published December 1970.

26. Engineering and Safety Reports, issued annually by National Tank Truck Carriers, Inc., Washington, D. C. 20036. Currently available: E & S Bulletin Nos. 61-A (November 1963), 68 (October 1965), 70 (December 1966), 72 (March 1968), 74 (November 1968), 77 (October 1969), and 80 (December 1970).

27. Railroad Accident Report, Crete, Neb., February 18, 1969. National Transportation Safety Board, U. S. Department of Transportation, Washington, D. C. 20591; Report No. NTSB-RAR-71-2, February 24, 1971.

28. Railroad Accident Report, Dunreith, Ind., January 1, 1968. National Transportation Safety Board, U. S. Department of Transportation, Washington, D. C. 20591. Report No. SS-R-2, December 18, 1968.

29. Railroad Accident Report, Laurel, Miss., January 25, 1969. National Transportation Safety Board, U. S. Department of Transportation, Washington, D. C. 20591; Report unnumbered, October 6, 1969.

30. Railroad Accident Report, Glendora, Miss., September 11, 1969. National Transportation Safety Board, U. S. Department of Transportation, Washington, D. C. 20591. Report No. NTSB-RAR-70-2, August 19, 1970.

31. 92nd Congress, 1st Session. Control of Hazardous Polluting Substances. Message from the President of the United States transmitting a Report on Control of Hazardous Polluting Substances pursuant to Section 12(g) of the Federal Water Pollution Control Act, as amended. (Via U. S. Coast Guard Department of Transportation). House Document No. 92-70. U. S. Government Printing Office.

32. See also Bibliography in above reference, on pages II-67 through II-73.

33. Elkins, H. B. The Chemistry of Industrial Toxicology. John Wiley & Sons, Inc., New York, N. Y. 10016, 1959; 2nd ed., 452 pp.

34. Smyth, H. F., Jr. Military and Space Short-Term Inhalation Standards. Archives of Environmental Health, Volume 12, 488-490, April 1966.

APPENDIX G

PARTICIPATING AGENCIES AND EQUIPMENT

G.1 PARTICIPATING AGENCIES OF A LOCAL CONTINGENCY PLAN

Section G.1, which begins on the next page, consists entirely of Table G-1, which is a list of typical participating agencies of a local Contingency Plan Organization. The reference text is Section 6.3. Members are marked by (M), Associates by (A).

Section G.2 consists entirely of a cross-indexed list of equipment and services available through the sources in Table G-1.

Agency	Type	Address (local, if available)	Telephone Number	Contact	Equipment and Services Available
Police Departments (M) (Specify by name)	City				Air compressors, canvas, ambulances, communications equipment, earth moving equipment, first aid, floodlights, hardware, emergency hospital, medical aid, paper supplies, stretchers, tents, tow trucks, traffic control, wreckers, protective clothing, evacuation routes, mobile radios.
Sheriff's Offices (M) (Specify by name)	County				
Highway Patrol (M)	State				
Fire Department (M) (Specify by name)	City				Ambulances, decontamination equipment, disaster assistance, toxic materials, firefighting equipment, oxygen, protective equipment, pumping units, rescue trucks, medical aid, rope and twine, hand tools, stretchers, tarpaulins.
Disaster and Civil Defense Office (M)	Federal - local and regional offices				Blankets, buses, canvas, cots, communications equipment, public announcements, drugs and medicine, first aid, hand tools, National Guard assistance, Federal assistance, rescue trucks, tarpaulins, tents.
Public Health Officer (M)	City County				Air pollution information, drugs and medicine, food poisoning treatment, immunization and general public health services, chemical analysis, water purification units.
Department of Public Health (M) or (A)	State				
U. S. Public Health Service (A)	Federal - local or regional offices				Packaged Disaster Hospitals, emergency medical supplies, blankets, cots, first aid stations, immunization, chemical analysis, public sanitation, Mobile Disaster Medical Teams.

Table G-1. Typical Participating Agencies of a Local Contingency Plan Organization

Agency	Type	Address (local, if available)	Telephone Number	Contact	Equipment and Services Available
Department of Hospitals (A) or (M)	City County State				Emergency hospital space and services.
Medical Examiner - Coroner (M)	City County				Identification, care, examination and removal of dead bodies.
Poison Control Center (Food and Drug Adm.) (A)	Federal - local office				Information and advice on ingested poisons.
Air Pollution Control Agency (M)	City County State				Chemical hazard detection, mobile laboratory, chemical analysis, prediction of hazard area, meteorological data, air contamination reports.
National Oceanographic and Atmospheric Adm. National Weather Service (A)	Federal - local office				Weather reports and forecasts, meteorological information for hazard area prediction.
Department of Highways and Traffic (M)	City State				Information: Highway hazards, traffic control, evacuation routes, road conditions.
Department of Public Works (M)	City State				Air compressors, cement, chemical toilets, dynamos and generators, earth moving equipment, hand tools, floodlights, hardware, emergency housing, mobile kitchens, plumbing supplies, rock, sand and gravel, heavy power equipment, tractors, dump trucks, welding equipment, wreckers.

Table G-1. (continued)

Agency	Type	Address (local, if available)	Telephone Number	Contact†	Equipment and Services Available
U. S. Coast Guard (M) or (A)	Federal - local or regional offices				On-Scene Commander for marine chemical spills, boats and barges emergency power equipment, first aid, pumping units, rope and twine, winch equipment, tarpaulins.
U. S. Army Corps of Engineers (A) or (M)	Federal - local or regional office				Air compressors, dynamos and generators, floodlights, hardware, power hoists, pumping units, rope and twine, hand tools, tow trucks, trenchers, tractors, water purification units, winches, wreckers.
National Guard (M) or (A)	State				Buses, first aid, rescue trucks, law enforcement assistance.
Office of Emergency Preparedness (A)	Federal - regional offices	Washington, D.C.	(202) 254-3111		Advisory and coordinating services on major disasters.
Department of Human Resources (or equivalent) (A)	State				Emergency manpower, rehabilitation.
Environmental Protection Agency Emergency Operations Control Center (A)	Federal-(regional offices)	Research Triangle Park, N. C.	(919) 549-8411 Ext. 2251 24 hrs/day	D. Tyler C. Whitmore or Duty Officer	Limited advisory only. Capability to offer wider variety of services is being developed.
American National Red Cross	Quasi-public local chapters				Disaster relief: emergency hospitals, cots, blankets, clothing, canteen service, housing, kitchen units, rehabilitation.

Table G-1. (continued)

Agency	Type	Address (local, if available)	Telephone Number	Contact	Equipment and Services Available
Salvation Army (A)	Quasi-public local chapters				Emergency clothing, canteen service, kitchen units, housing, rehabilitation
Industrial Mutual Aid Associations (M)	Private, with or without government members.				Air compressors, cement, chemical toilets, decontamination apparatus, disaster assistance on hazardous materials, fire-fighting equipment, power hoists, hydraulic jacks, stand-by power plants, aluminum pipe, plumbing supplies, pumping units, protective equipment, mobile radios, resuscitators, rock, sand and gravel, welding equipment. Also, emergency field crews.
Manufacturing Chemists Association Chemical Transportation Emergency Center (CHEMTREC) (A)	Trade Assoc.	1875 Connecticut Ave. Washington, D.C. 20009	(800) 424-9300* *483-7616 in Wash., D.C. area 24 hrs/day	Duty Officer	Information on chemical hazard, identification, shipper, manufacturer, carrier, shipper handling, neutralization, disposal, cleanup. Referral to emergency field crew associations.
National Agricultural Chemicals Association (A)	Trade Assoc., regional offices	Cincinnati, Ohio (headquarters)	(513) 961-4300 (headquarters) 24 hrs/day	Pesticide Safety Team	Safety teams to neutralize and remove spills of pesticides and other chemicals; also information on manufacture, characteristics, neutralization, and disposal of wide variety of chemicals.
The Chlorine Institute, Inc. (A)	Trade Assoc., regional offices	342 Madison Ave. New York, N.Y. 10017	(212) MU2-4324	Mr. Mitchell Mr. Laubusch	Emergency response teams specializing in releases of chlorine gas and compounds; containment, neutralization, disposal, cleanup.

Table G-1. (continued)

Agency	Type	Address (local, if available)	Telephone Number	Contact	Equipment and Services Available
National Defense Transportation Association (A) or (M)	Trade Assoc., 105 local chapters	1612 K St., N.W. Washington, D.C. (headquarters) 20006	(202) DI7-3530 (headquarters) 24 hrs/day	Disaster Staff	Emergency transportation and vehicles of all kinds, also coordination on needs and supplies of automotive, rail and waterborne transportation.
Railway Systems and Management Assoc. (A)	Trade Assoc.	181 East Lake Shore Drive, Chicago, Ill. 60611	(312) 943-5542	Mr. Leviton Mr. Vietsch	Information on hazardous chemicals; properties, handling, neutralization, cleanup, disposal, medical treatment, emergency equipment and manpower resources.
American Trucking Associations (A)	Trade Assoc.	1616 P Street, N.W. Washington, D.C. 20036	(202) 269-3337	Safety	Information on manufacturer, shipper, and carrier of motor vehicle-borne hazardous material; also handling advice.
(National Tank Truck Carriers, Inc)			(202) 269-3425	C. Harvison	
Association of American Railroad, Bureau of Explosives (A)	Trade Assoc., Regional field inspectors	1920 L Street, N.W. Washington, D.C. 20036	(202) 293-4048 24 hrs/day	R. Graziano	Inspectors (11 in USA, 2 in Canada) to assist rail carrier at episode scene with expertise and operational advice.
Association General Contractors of America "Plan Bulldozer" (A) or (M)	Trade Assoc., 126 local chapters	1957 E St., N.W. Washington, D.C. (headquarters) 20006	(202) 393-2040 (headquarters) 24 hrs/day	Disaster Staff	Boats and barges, cement, earth moving equipment, debris removal, power hoists, hydraulic jacks, plumbing supplies, rock, sand and gravel, tractors, trenchers, welding equipment, winch equipment.
Local Carriers: Railroad companies Steamship and barge companies Major tank truck companies Pipeline companies (M)	Transportation				Work crews, supervisors, inspectors, and other field personnel.

Table G-1. (continued)

Agency	Type	Address (local, if available)	Telephone Number	Contact	Equipment and Services Available
Local news media: Newspapers Radio stations Television stations (M)	Public information				Dissemination of news, reports, and instructions. Communications assistance, equipment.

Table G-1. (continued)

G.2 SOURCES FOR EQUIPMENT AND SERVICES (See Directory for Addresses) (Generally acquired through Disaster Services Coordinator)

Item	Order of Contact	Agency
Acetylene Torches		See Welding Equipment
Air Compressors	1	City Police Department
	2	U. S. Army Corps of Engineers
	3.	Industry Mutual Aid Association
	4.	Department of Public Works
Air Pollution Information	1.	Air Pollution Control Agency
	2.	County Public Health Officers
Aluminum Pipe		
Ambulances (also see Rescue Trucks)	1.	City Fire Department (Rescue Squad)
	2.	Disaster and Civil Defense Commission
	3.	City Police Department
Blankets	1.	Disaster and Civil Defense Commission
	2.	American National Red Cross
	3.	U. S. Public Health Service
Boats and Barges	1.	U. S. Coast Guard
	2.	Assoc. Gen. Contractors of America
Bodies, Dead	1.	Chief Medical Examiner-Coroner
Bulldozers		See Earth Moving Equipment
Buses	1.	Disaster and Civil Defense Commission
	2.	State National Guard
	3.	Natl. Defense Transportation Assn.
Canteen Service, Mobile	1.	American Natl. Red Cross
	2.	Salvation Army
Canvas	1.	Disaster and Civil Defense Commission
	2.	City Police Department
	3.	State National Guard
Cement	1.	Department of Public Works
	2.	Industry Mutual Aid Association
	3.	Assoc. Gen. Contractors of America
Chemical Toilets, Portable	1.	Industry Mutual Aid Association
	2.	Assoc. Gen. Contractors of America
	3.	Department of Public Works

Clothing Donations, Emergency	1.	American National Red Cross
	2.	Salvation Army
Communications Equipment	1.	Disaster and Civil Defense Commission
	2.	City Police Department
	3.	News Media
Compressors		See Air Compressors
Coroner	1.	County Chief Medical Examiner-Coroner
Cots	1.	U. S. Public Health Service
	2.	American National Red Cross
Cranes		See Earth Moving Equipment
Crowbars		See Hardware
Declaration of State of Disaster (State or Federal)	1.	Governor
	2.	Chairman, Disaster and Civil Defense Commission
Decontamination Apparatus	1.	City Fire Department
	2.	Industry Mutual Aid Association
	3.	Chlorine Institute, Pesticide Safety Team, etc. (based on chemical released)
Detection, Chemical Hazard		See Hazard, Chemical Identification
Disaster Assistance, Toxic Materials	1.	City Fire Department
	2.	Industry Mutual Aid Association
	3.	Chlorine Institute, Pesticide Safety Team, etc. (based on chemical released)
Drugs and Medicine	1.	U. S. Public Health Service
	2.	State Department of Health
	3.	County Medical Association
	4.	County Public Health Officers
Dynamos and Generators	1.	U. S. Army Corps of Engineers
	2.	U. S. Coast Guard
	3.	Department of Public Works
Earth Moving Equipment	1.	Assoc. Gen. Contractors of America
	2.	City Police Department
	3.	Department of Public Works
Employment Assistance	1.	State Department of Human Resources
Evacuation Routes	1.	Department of Highways and Traffic
	2.	State Highway Patrol

Feeding during Disasters (Victims and Workers)	1.	American National Red Cross
	2.	Salvation Army
Fire Equipment (See Footnote 1)	1.	City Fire Department
	2.	Industry Mutual Aid Association
First Aid	1.	County Sheriff's Office
	2.	City Police Department
	3.	State National Guard
	4.	U. S. Coast Guard
First Aid Stations	1.	U. S. Public Health Service
	2.	State Department of Health
Floodlights	1.	County Sheriff's Office
	2.	City Police Department
	3.	U. S. Army Corps of Engineers
	4.	Department of Public Works
Food Poisoning Treatment	1.	County Public Health Officer
	2.	Poison Control Center
	3.	U. S. Public Health Service
Generators		See Dynamos
Gas Masks		See Protective Equipment
Gloves		See Protective Equipment
Graders	1.	City Police Department
	2.	Assoc. Gen. Contractors of America
	3.	Department of Public Works
Gravel		See Rock
Hammers		See Hardware
Hardware	1.	Department of Public Works
	2.	City Police Department
	3.	Industry Mutual Aid Association
	4.	U. S. Corps of Engineers
Health, Public	1.	U. S. Public Health Service
	2.	State Department of Health
	3.	County Public Health Officer
Highway Hazards	1.	State Highway Patrol
	2.	Assoc. Gen. Contractors of America
	3.	Department of Highways and Traffic
Hoes, Hand	1.	City Police Department
	2.	Department of Public Works

Hoists, Power	1.	Department of Public Works
	2.	Industry Mutual Aid Association
	3.	Assoc. Gen. Contractors of America
	4.	U. S. Army Corps of Engineers
Hose	1.	City Fire Department
	2.	Industry Mutual Aid Association
Hazard, Chemical: Information and Advice	1.	Manufacturing Chemists Association
	2.	Air Pollution Control Agency
	3.	Industry Mutual Aid Association
Hospitals, Emergency (also see First Aid)	1.	U. S. Public Health Service
	2.	American National Red Cross
	3.	City Police Department
	4.	State Department of Health
Hospitals, 200 Bed Units	1.	U. S. Public Health Service
	2.	State Department of Health
Housing, Emergency	1.	Department of Public Works
	2.	American National Red Cross
	3.	Salvation Army
Immunizations, Medical	1.	U. S. Public Health Service
	2.	County Public Health Officer
Jacks, Hydraulic	1.	Department of Public Works
	2.	Industry Mutual Aid Association
	3.	Assoc. Gen. Contractors of America
Kitchen Units, Mobile	1.	Department of Public Works
	2.	American National Red Cross
	3.	Salvation Army
Lights, Portable	1.	County Sheriff's Office
	2.	City Police Department
	3.	U. S. Army Corps of Engineers
	4.	Department of Public Works
Loaders, Front End	1.	Department of Public Works
	2.	Industry Mutual Aid Association
	3.	Assoc. Gen. Contractors of America
Manpower, Emergency	1.	State Department of Human Resources
Marine Chemical Spill	1.	U. S. Coast Guard
Medical Aid, Emergency	1.	County Sheriff's Office
	2.	City Police Department
	3.	State Disaster and Civil Defense Commission
	4.	U. S. Public Health Service

Medicine		See Drugs and Medicine
Mobile Kitchen Units		See Kitchen Units
Meteorological Information (Weather Prediction)	1.	U. S. Dept. of Commerce, National Weather Service
	2.	City Air Pollution Control Agency
	3.	News Media
Mobile Stand-by Power Plants	1.	Department of Public Works
	2.	Industry Mutual Aid Association
	3.	U. S. Army Corps of Engineers
Mortician Supplies	1.	County Chief Medical Examiner-Coroner
Mobile Laboratory, Chemical Analysis	1.	City Air Pollution Control Agency
	2.	U. S. Public Health Service
	3.	State Department of Health
Nails		See Hardware
National Guard Assistance (Law Enforcement, etc.)	1.	County Sheriff's Office
	2.	State Disaster and Civil Defense Commission
	3.	State National Guard
Nozzles		See Fire Equipment
Office of Emergency Preparedness, Federal Assistance	1.	State Disaster and Civil Defense Commission
Oxygen, Medical	1.	Fire Department Rescue Squad
	2.	Disaster and Civil Defense Commission
	3.	State Highway Patrol
Paper Supplies	1.	County Sheriff's Office
	2.	City Police Department
Personnel, Emergency	1.	State Department of Human Resources
Pipe, Aluminum (6") (Fire Fighting)	1.	City Fire Department
	2.	Industry Mutual Aid Association
Plumbing Supplies	1.	Department of Public Works
	2.	Industry Mutual Aid Association
	3.	Assoc. Gen. Contractors of America
Poisons, Information and Advice		See Hazards, Chemical
Pollution, Air Information	1.	Air Pollution Control Agency

Prediction, Weather	1.	U. S. Department of Commerce, National Weather Service
	2.	City Air Pollution Control Agency
	3.	News Media
Prediction, Hazard Area	1.	City Air Pollution Control Agency
Protective Equipment (Clothing, Gloves, Gas Masks)	1.	County Sheriff's Office
	2.	City Fire Department
	3.	Industry Mutual Aid Association
Pumping Units	1.	City Fire Department
	2.	Industry Mutual Aid Association
	3.	U. S. Army Corps of Engineers
	4.	U. S. Coast Guard
Radios, Mobile	1.	State Highway Patrol
	2.	Industry Mutual Aid Association
	3.	City Police Department
Rescue Trucks	1.	Disaster and Civil Defense Commission
	2.	State National Guard
	3.	Natl. Defense Transportation Assn.
	4.	City Fire Department
Resuscitators, Portable (also see First Aid)	1.	City Fire Department
	2.	City Police Department
	3.	Industry Mutual Aid Association
	4.	U. S. Public Health Service
Road Conditions	1.	State Highway Patrol
	2.	News Media
	3.	Department of Highways and Traffic
Rock, Sand and Gravel	1.	Department of Public Works
	2.	Industry Mutual Aid Association
	3.	Assoc. Gen. Contractors of America
Rope and Twine	1.	City Fire Department
	2.	U. S. Army Corps of Engineers
	3.	U. S. Coast Guard
Sanitation, Public	1.	U. S. Public Health Service
	2.	State Department of Health
	3.	U. S. Army Corps of Engineers
Scrapers, Earth	1.	Department of Public Works
	2.	Industry Mutual Aid Association
	3.	Assoc. Gen. Contractors of America
Shovels, Power	1.	Department of Public Works
	2.	U. S. Army Corps of Engineers
	3.	Assoc. Gen. Contractors of America

Shovels, Hand Tools, etc.	1.	Disaster and Civil Defense Commission
	2.	U. S. Army Corps of Engineer
	3.	City Fire Department
	4.	Department of Public Works
State of Disaster Declaration (State or Federal)	1.	Governor, of State
	2.	Chairman, State Disaster and Civil Defense Commission
Stretchers	1.	City Fire Department
	2.	City Police Department
	3.	Disaster and Civil Defense Commission
Surgical Supplies (also see Drugs and First Aid)	1.	U. S. Public Health Service
	2.	State Department of Health
	3.	County Medical Association
Tarpaulins	1.	Disaster and Civil Defense Commission
	2.	U. S. Coast Guard
	3.	City Fire Department
	4.	State National Guard
Tents	1.	Disaster and Civil Defense Commission
	2.	State National Guard
	3.	City Police Department
Tools, Hand (also see Hardware, Plumbing, etc.)		See Shovels, Hand Tools, etc.
Torches, Acetylene		See Welding Equipment
Tow Trucks (also see Trucks and Wreckers)	1.	County Sheriff's Office
	2.	City Police Department
	3.	U. S. Army Corps of Engineers
	4.	Natl. Defense Transportation Assn.
Tractors	1.	Department of Public Works
	2.	Assoc. Gen. Contractors of America
	3.	U. S. Army Corps of Engineers
Transportation, common and proprietary carriers	1.	National Defense Transportation Assn.
Traffic Control	1.	State Highway Patrol
	2.	City Police Department
	3.	County Sheriff's Office
	4.	Department of Highways and Traffic
Trenchers	1.	Department of Public Works
	2.	Assoc. Gen. Contractors of America
	3.	U. S. Army Corps of Engineers

Trucks, Dump and General Hauling (also see Tow Trucks and Wreckers)	1.	Department of Public Works
	2.	U. S. Army Corps of Engineers
	3.	Assoc. Gen. Contractors of America
Undertaking Supplies		See Mortician Supplies
Walkie Talkies		See Radios
Water Purification Units	1.	U. S. Public Health Service
	2.	County Public Health Officers
	3.	U. S. Army Corps of Engineers
Weather Reports	1.	U. S. Department of Commerce, National Weather Service
	2.	News Media
	3.	State Highway Patrol
	4.	Air Pollution Control Agency
Welding Equipment	1.	Department of Public Works
	2.	U. S. Army Corps of Engineers
	3.	Assoc. Gen. Contractors of America
	4.	Industry Mutual Aid Association
Winch Equipment (also see Hoists and Wreckers)	1.	Department of Public Works
	2.	U. S. Army Corps of Engineers
	3.	U. S. Coast Guard
	4.	Assoc. Gen Contractors of America
Workers, Emergency	1.	State Department of Human Resources
Wreckers, Automotive (also see Hoists, Tow Trucks, and Winch Equipment)	1.	Department of Public Works
	2.	County Sheriff's Office
	3.	City Police Department
	4.	U. S. Army Corps of Engineers

A

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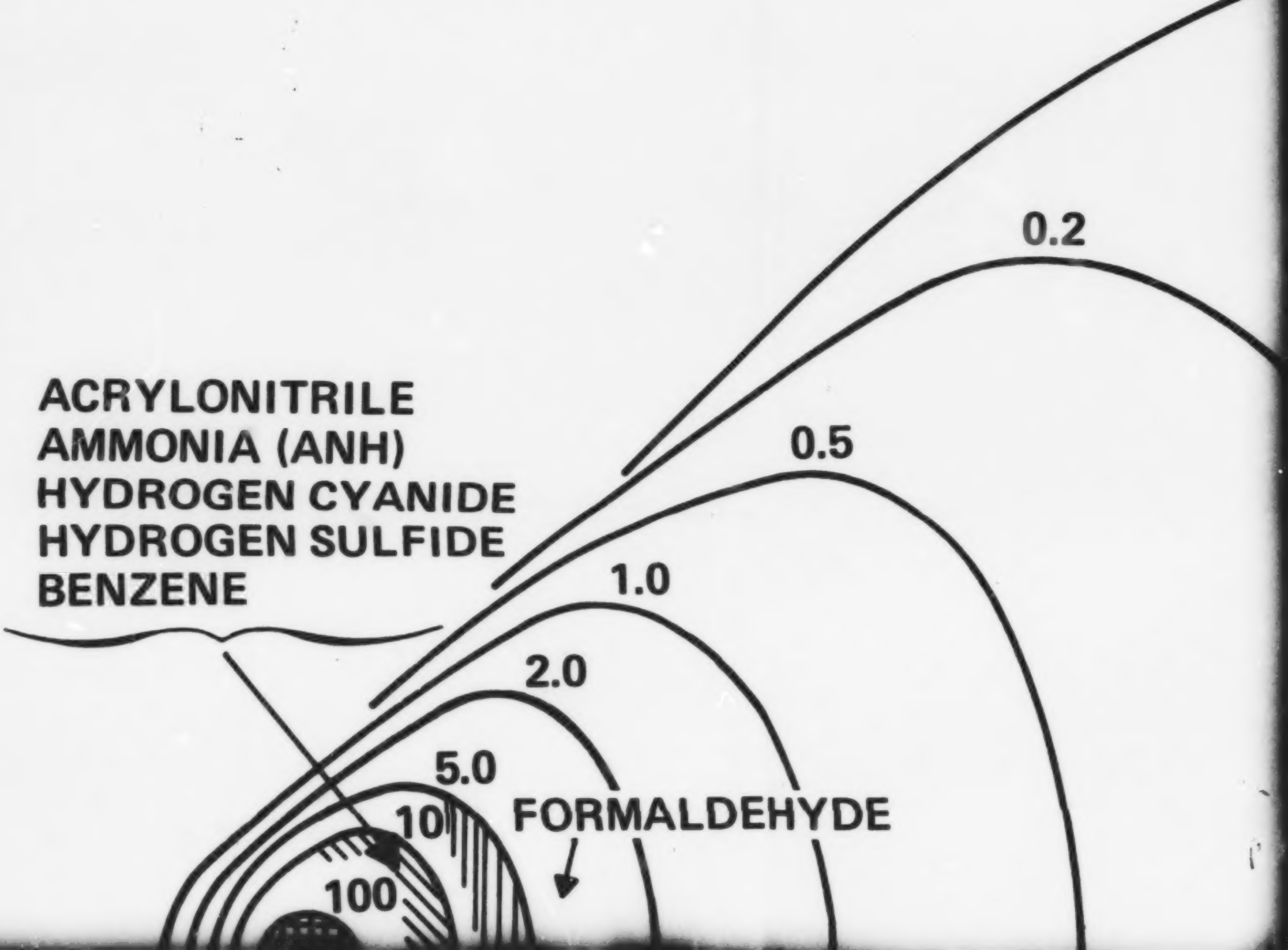

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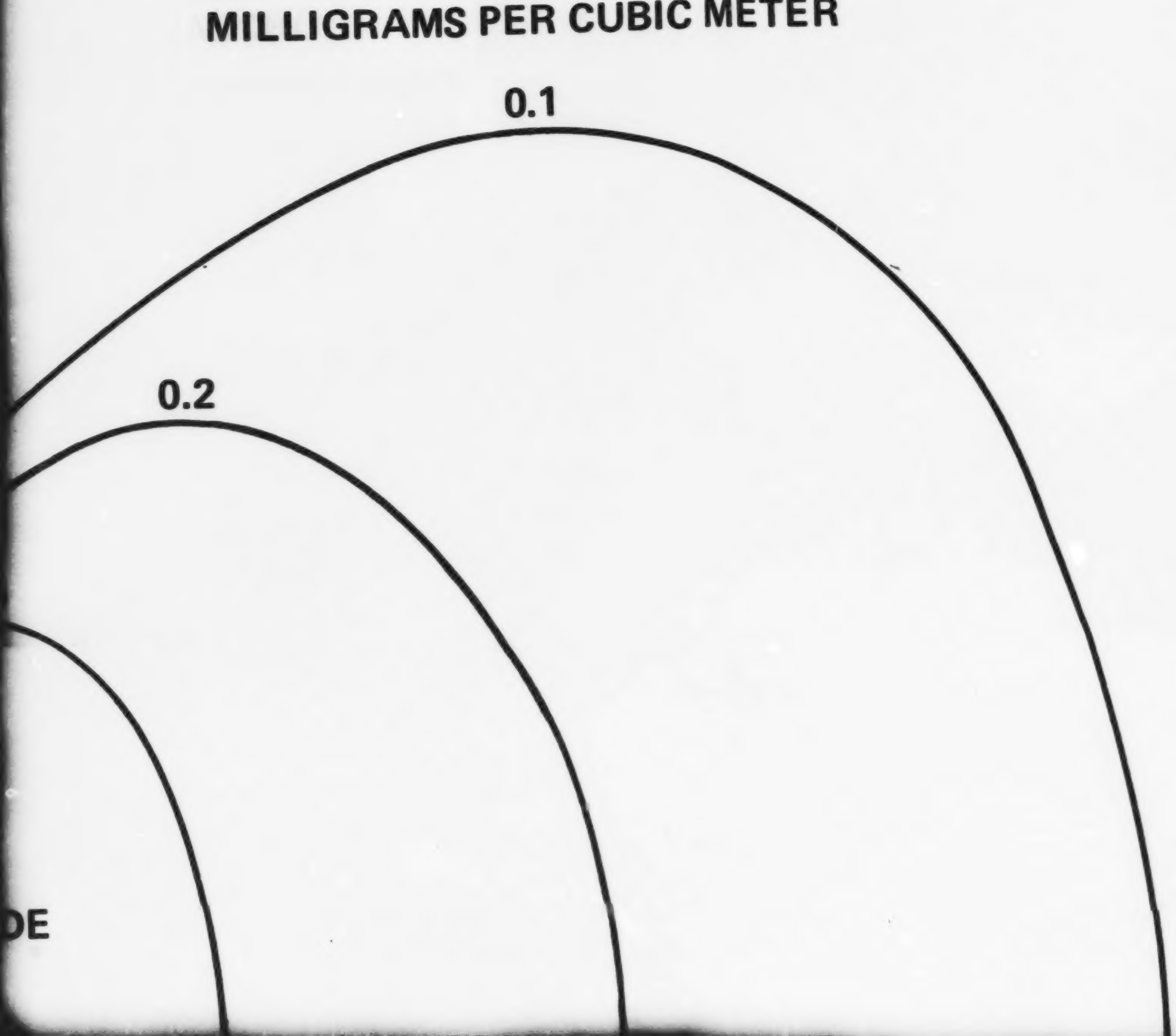

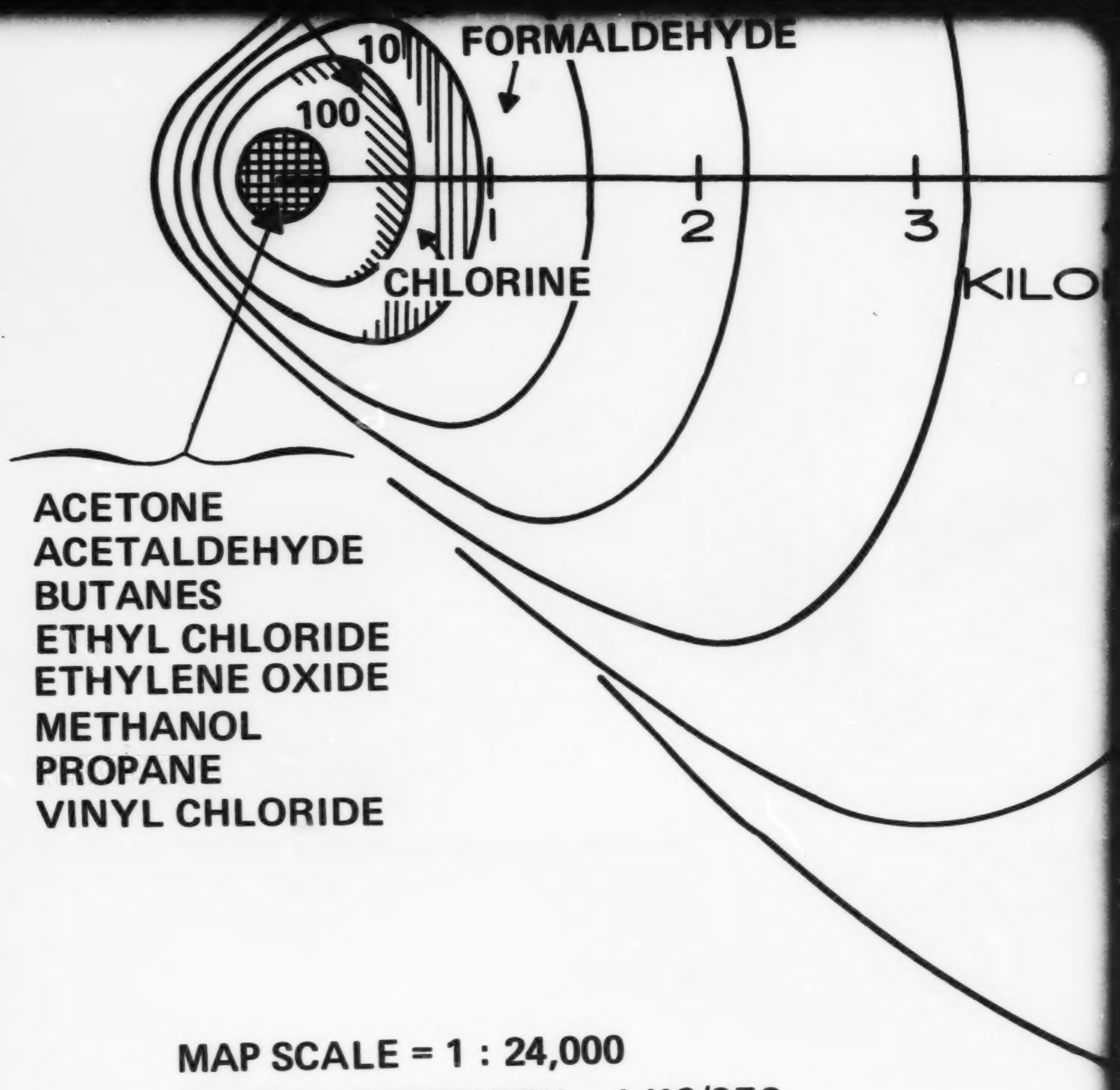
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SOURCE STRENGTH = 1 KG/SEC.
WIND SPEED = 3 M/SEC.

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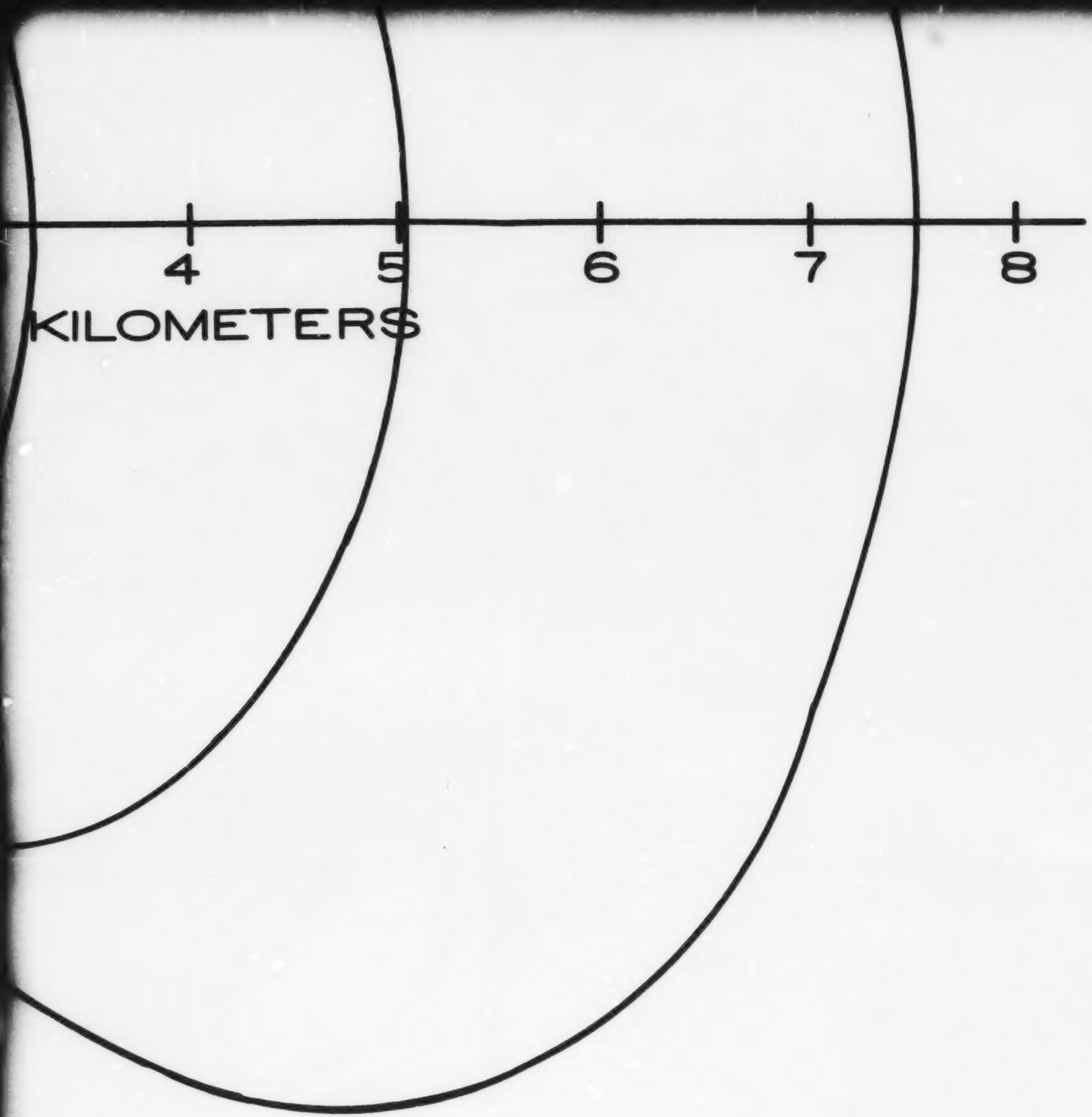

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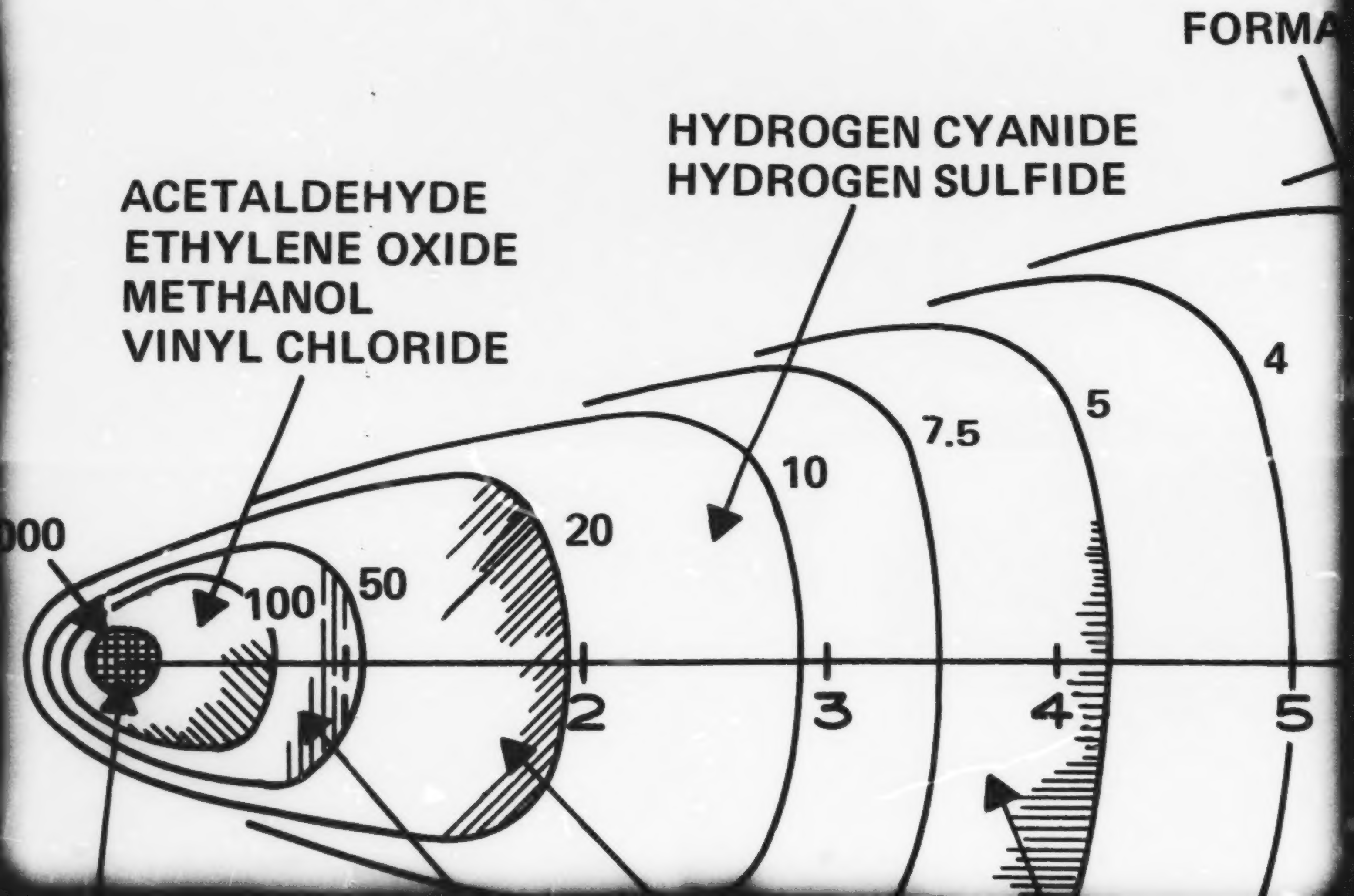

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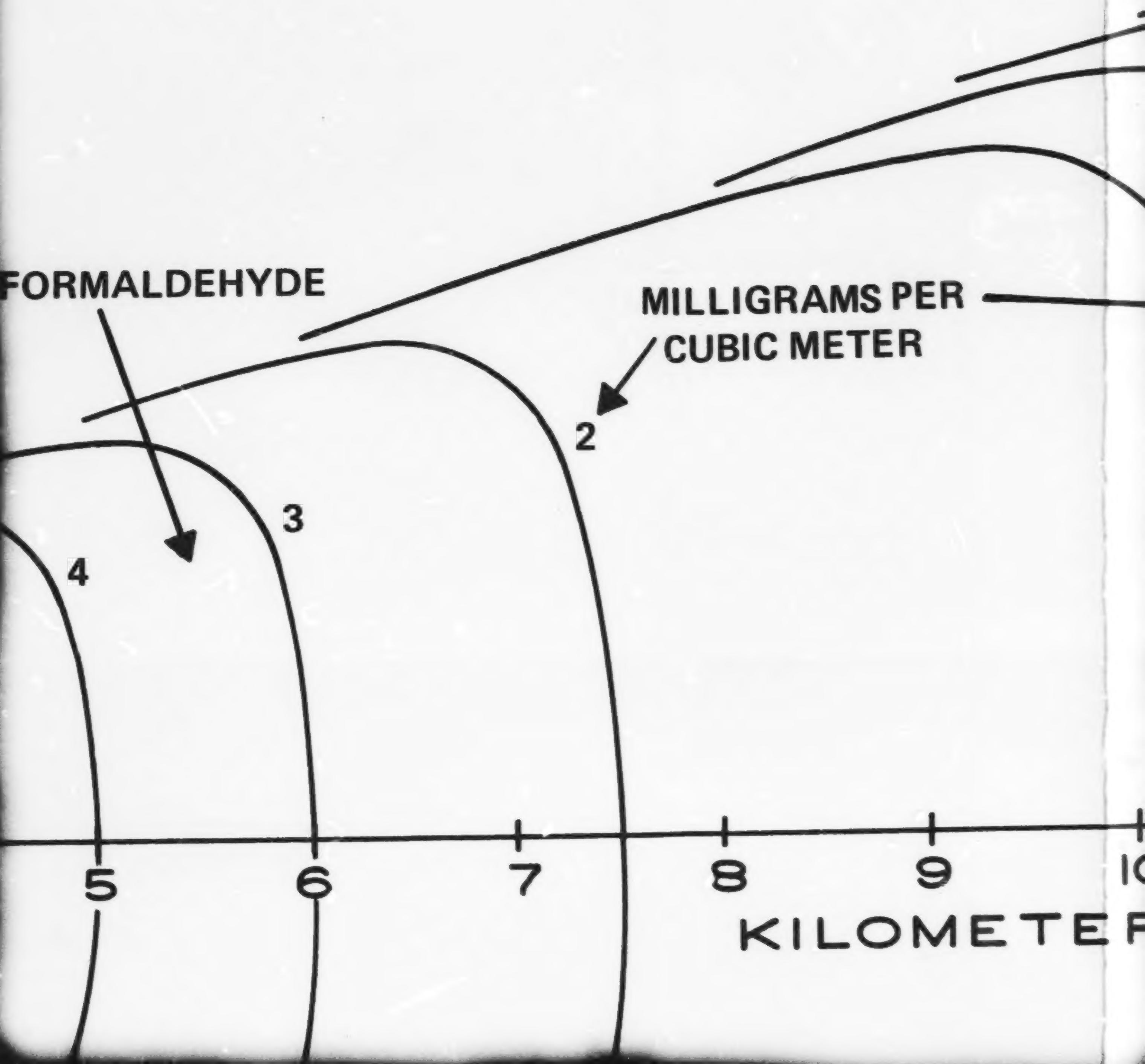

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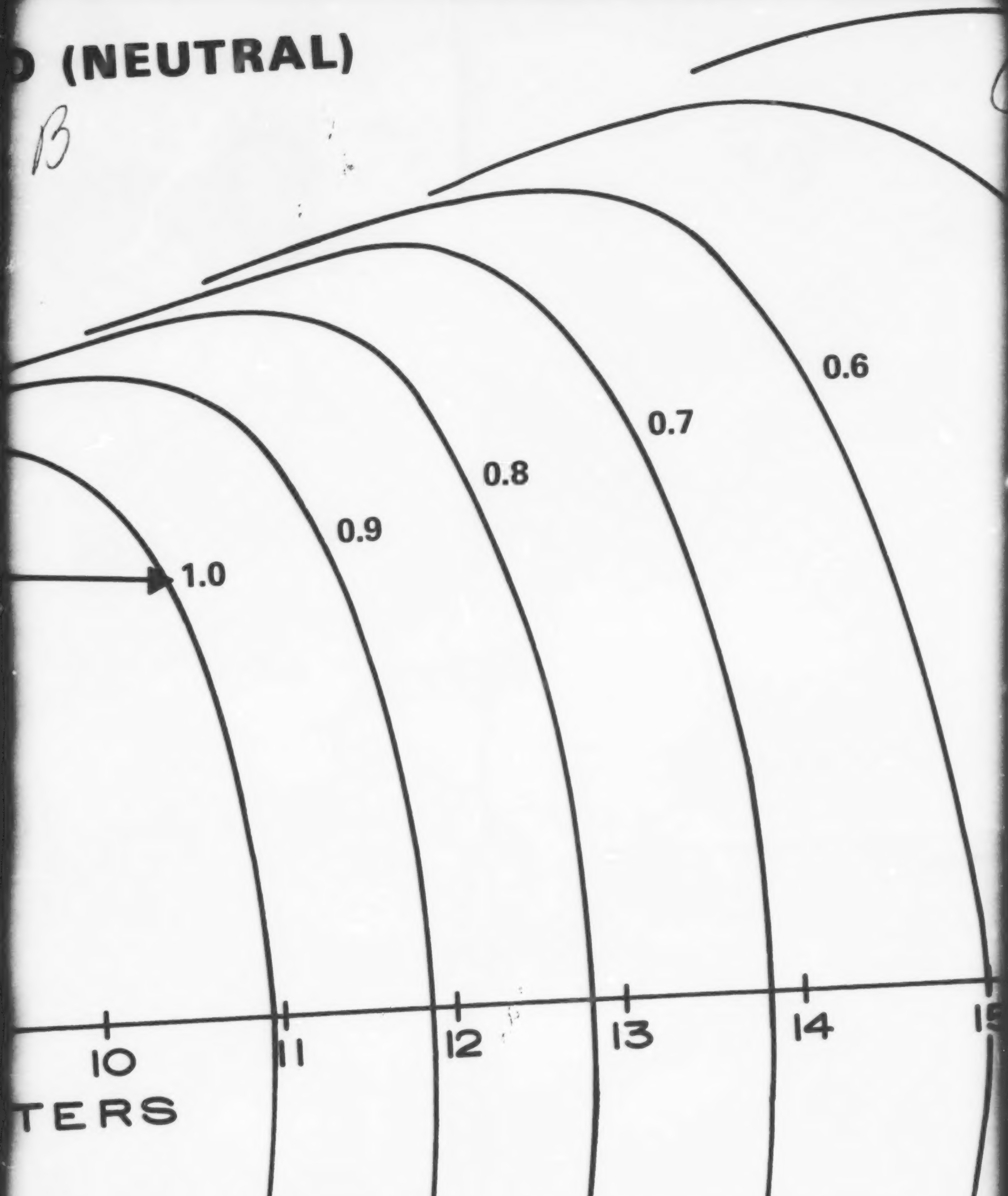

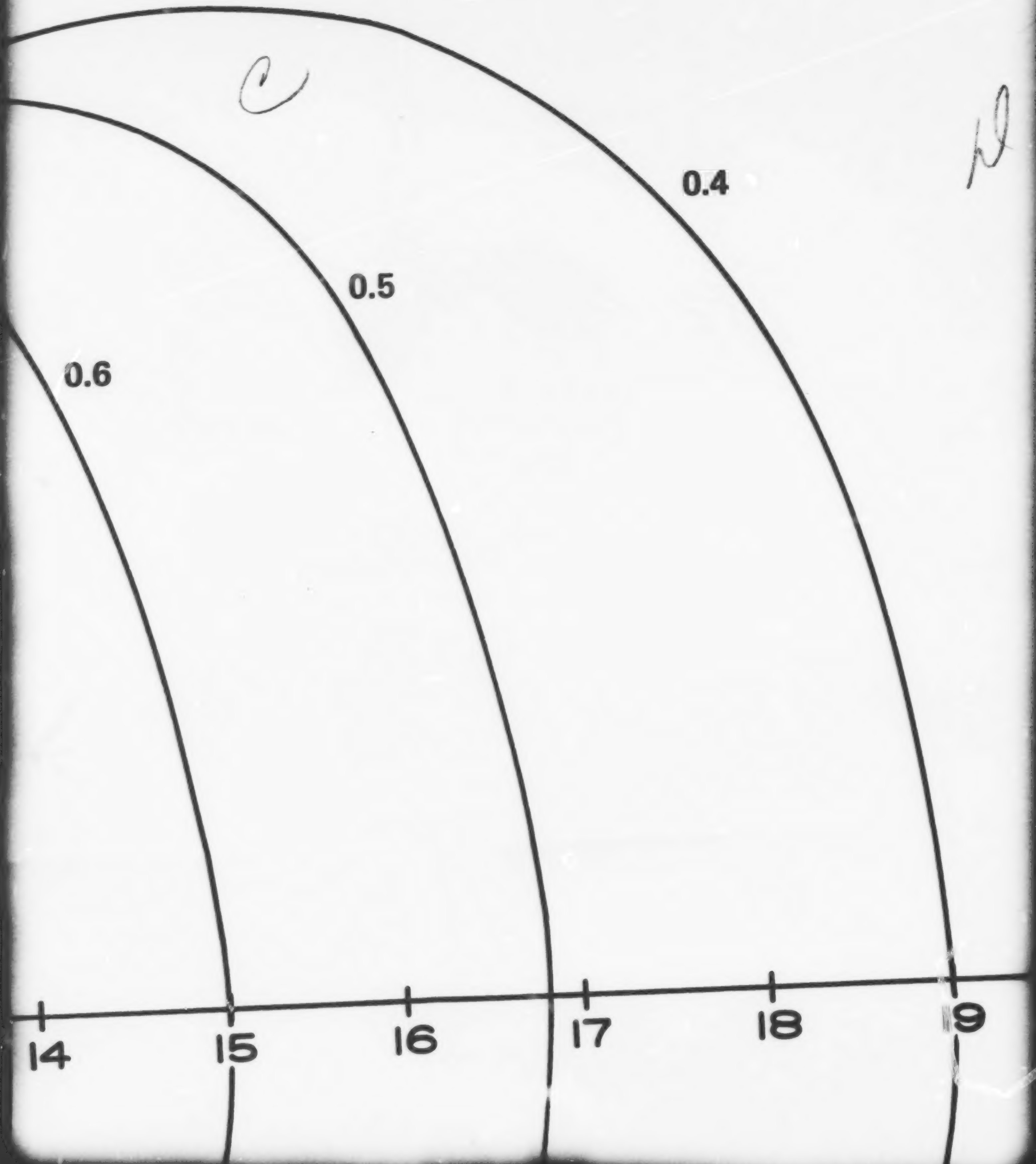
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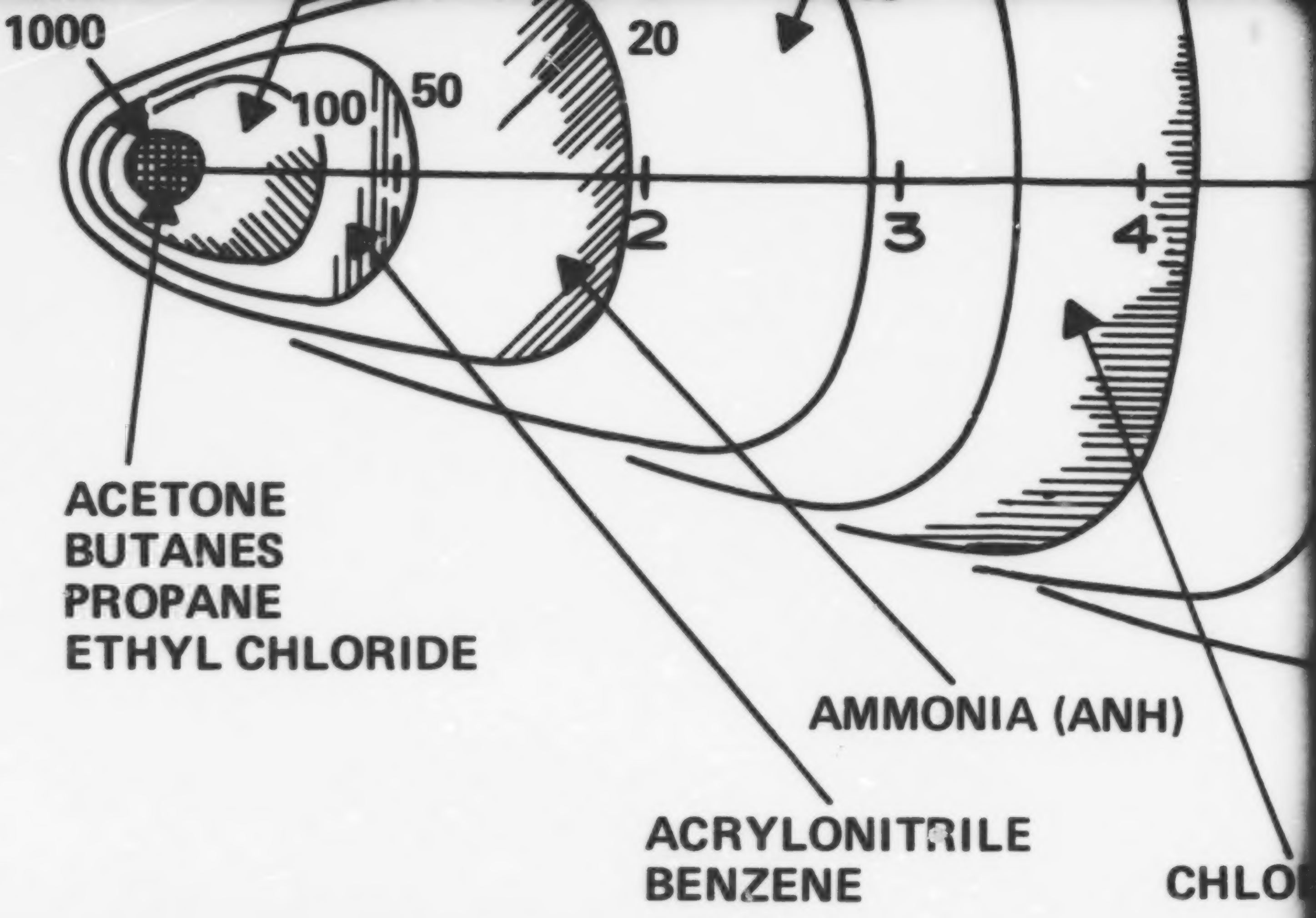
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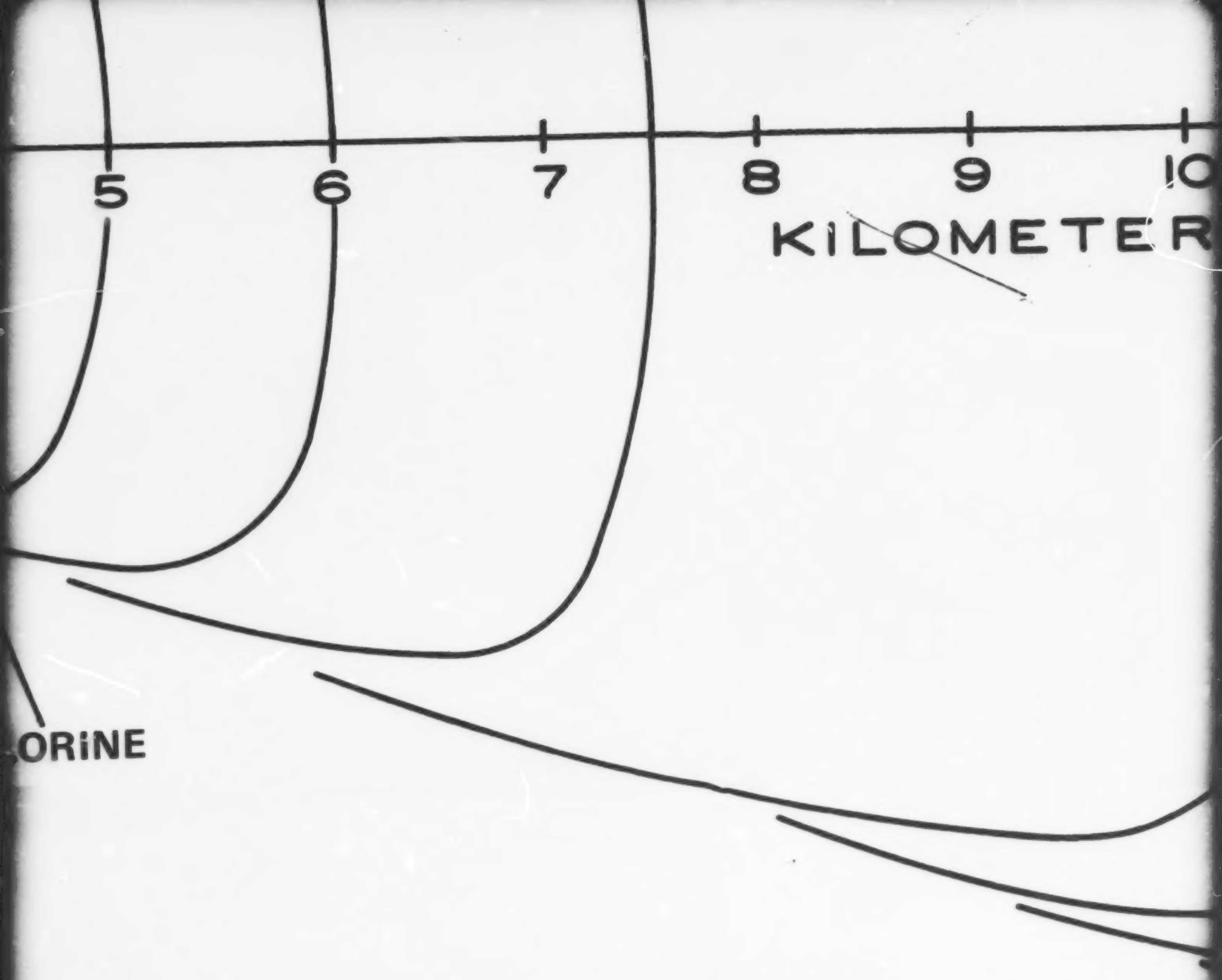
WIND SPEED = 3 M/SEC.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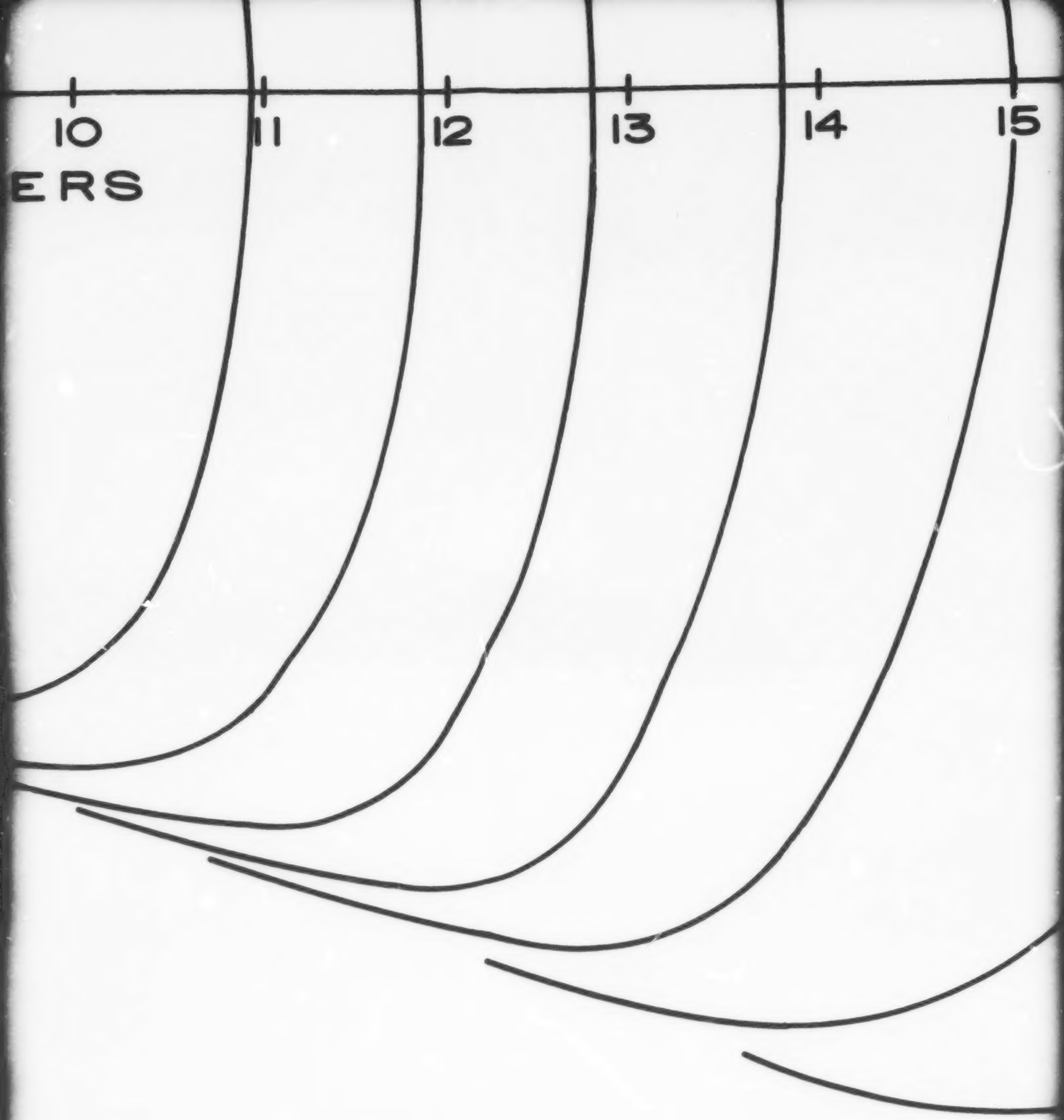

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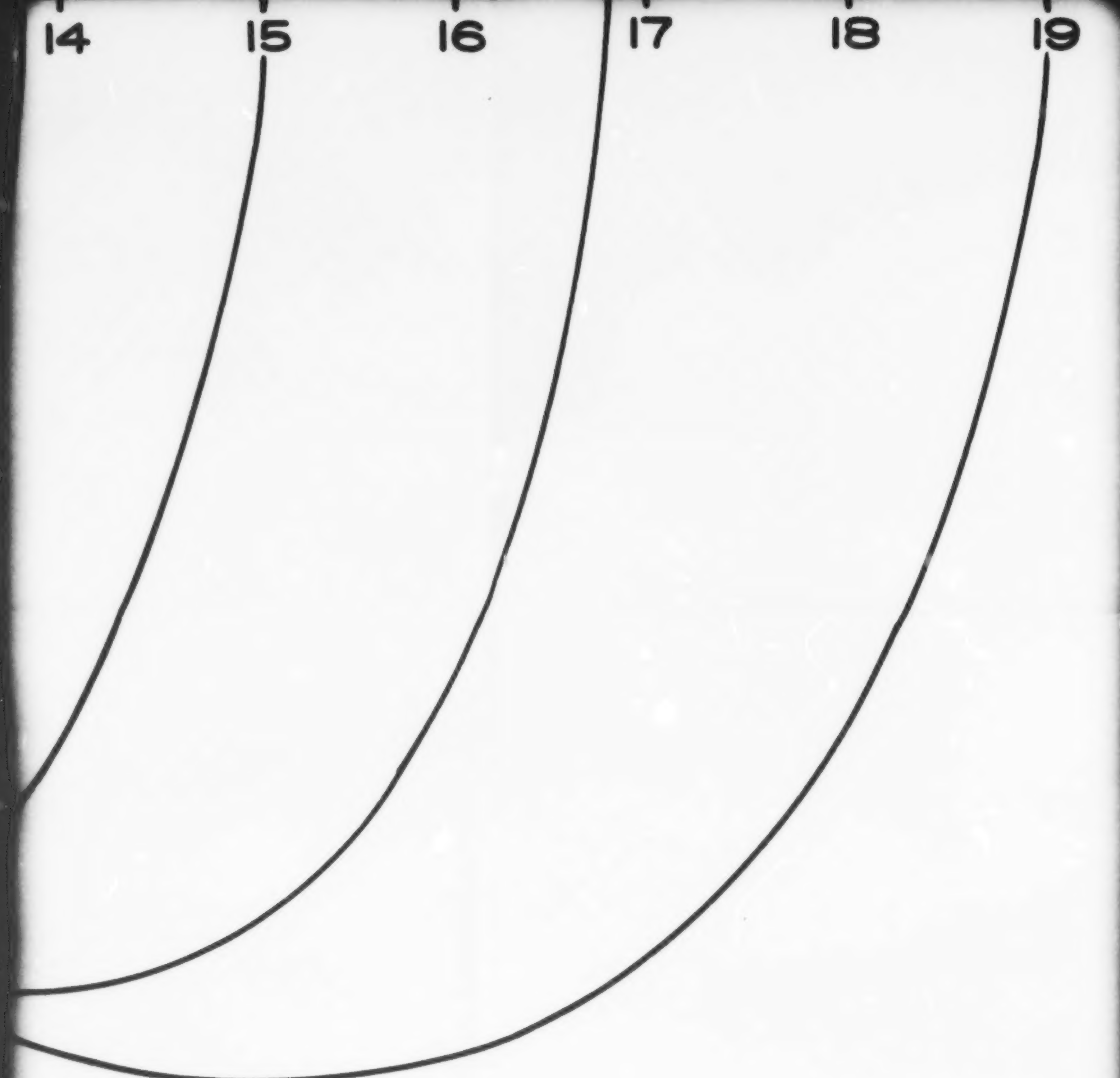
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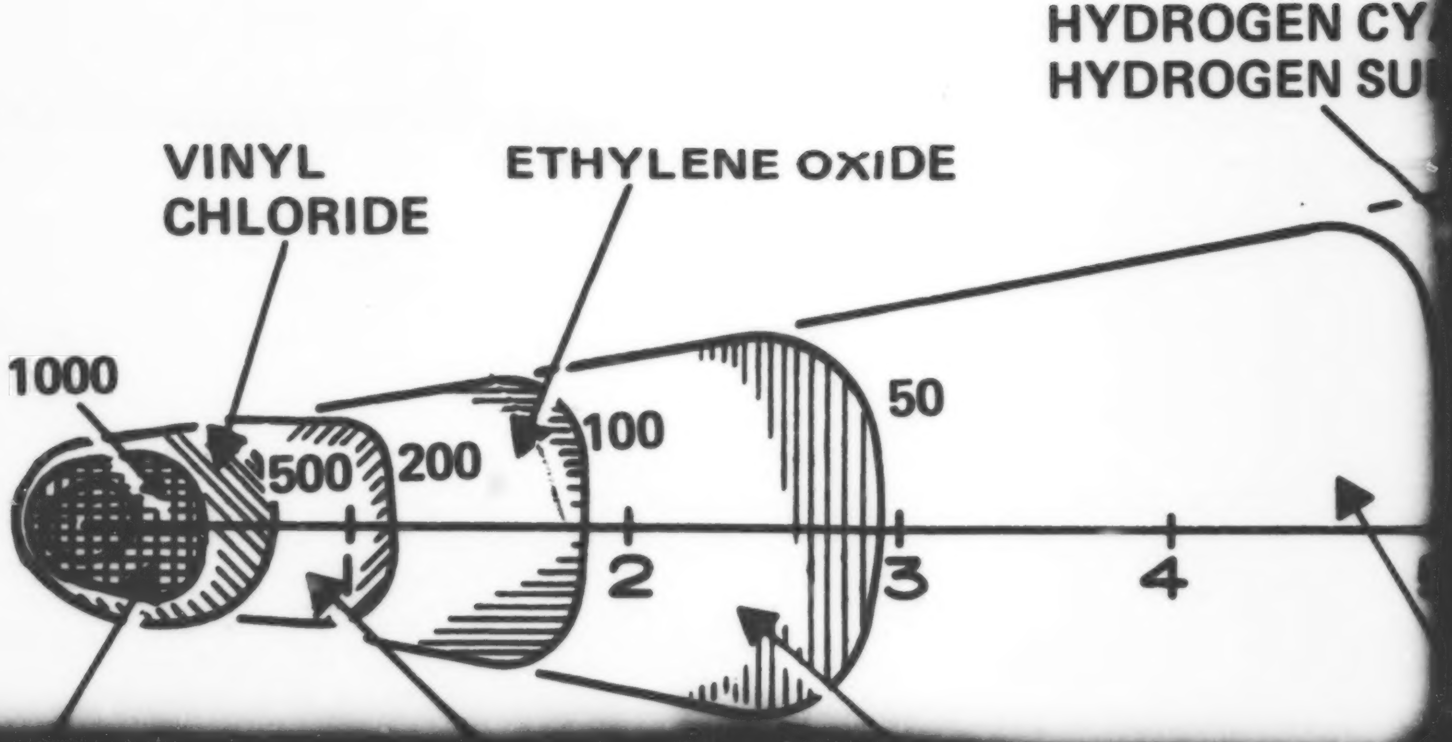
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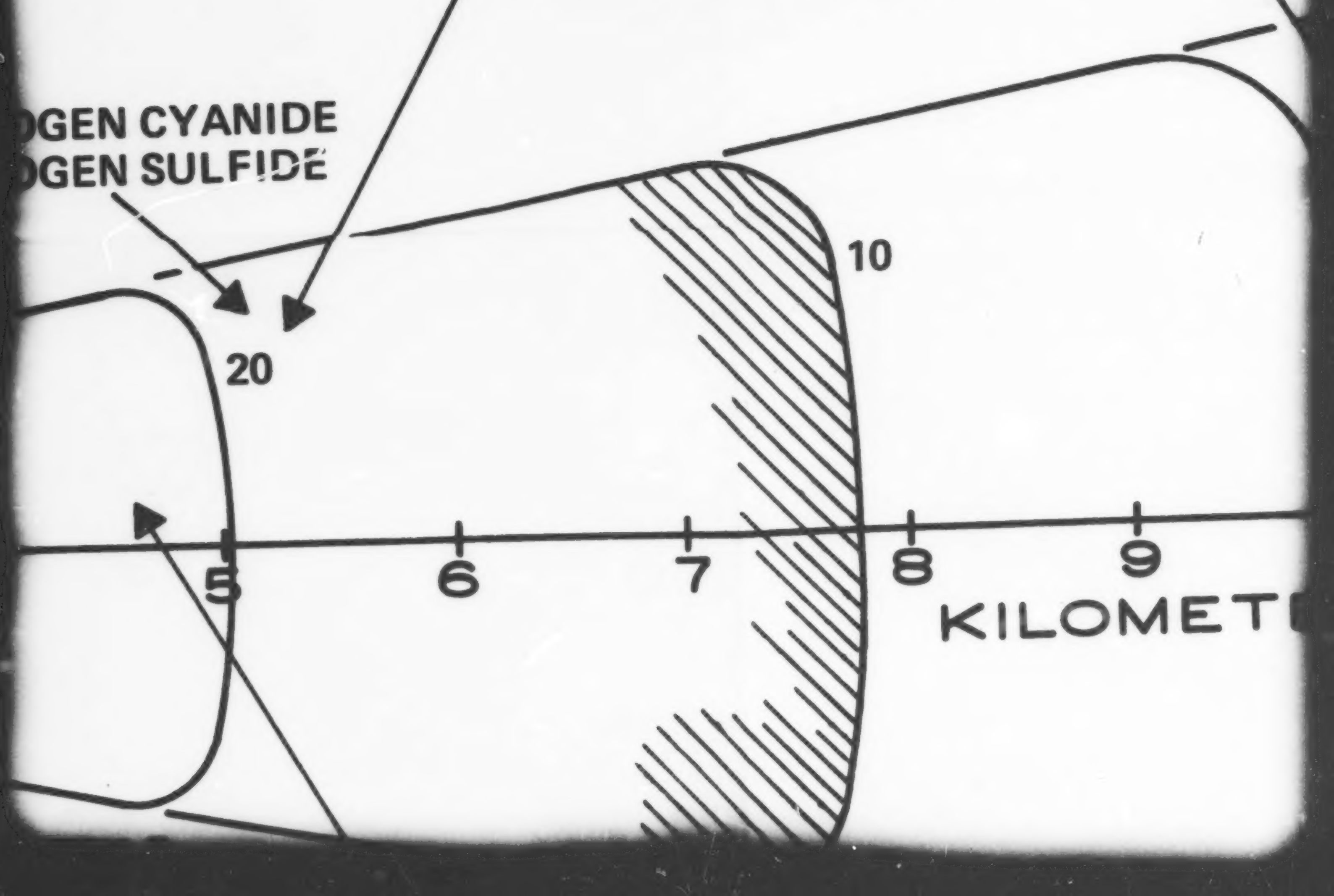

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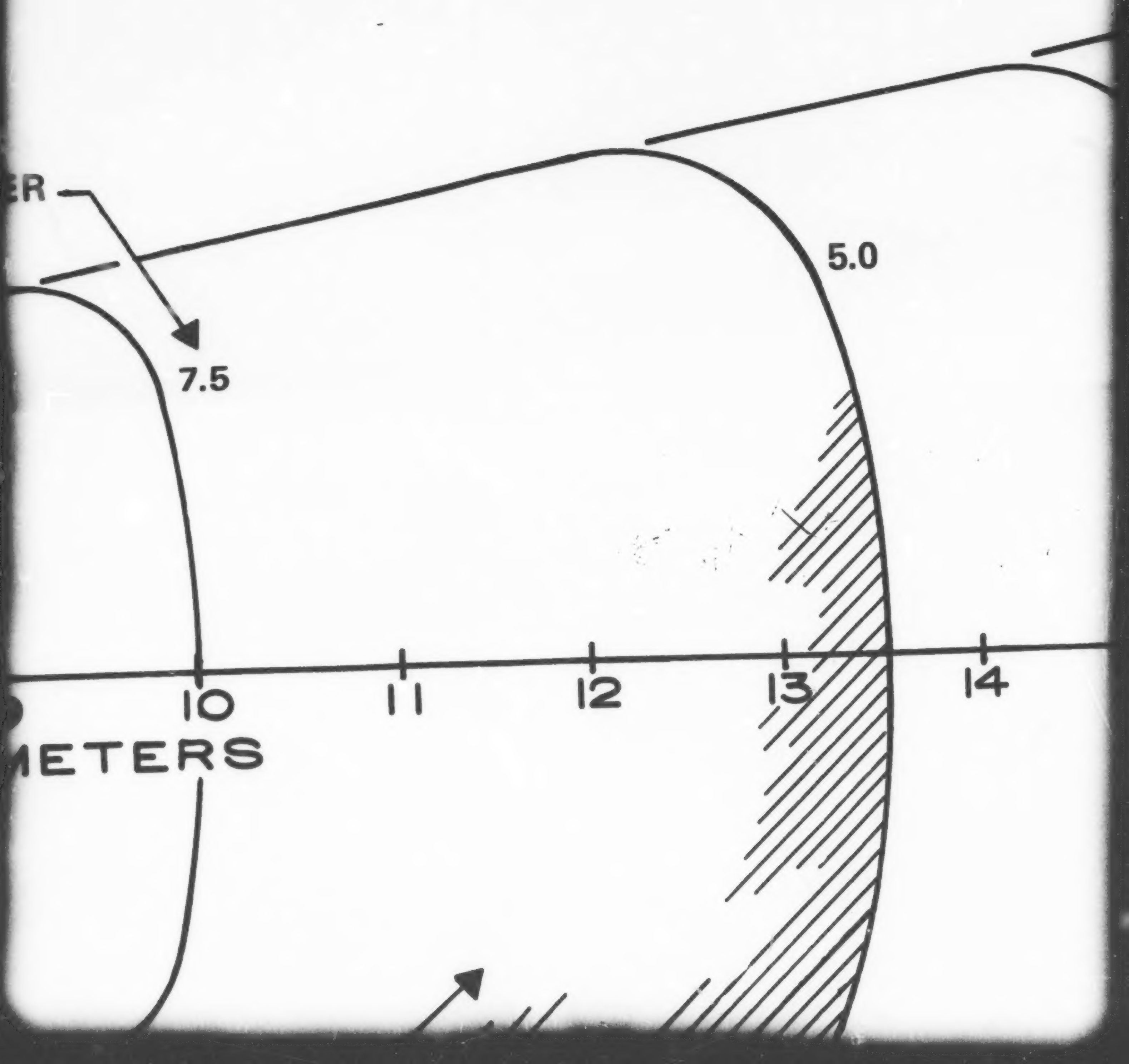

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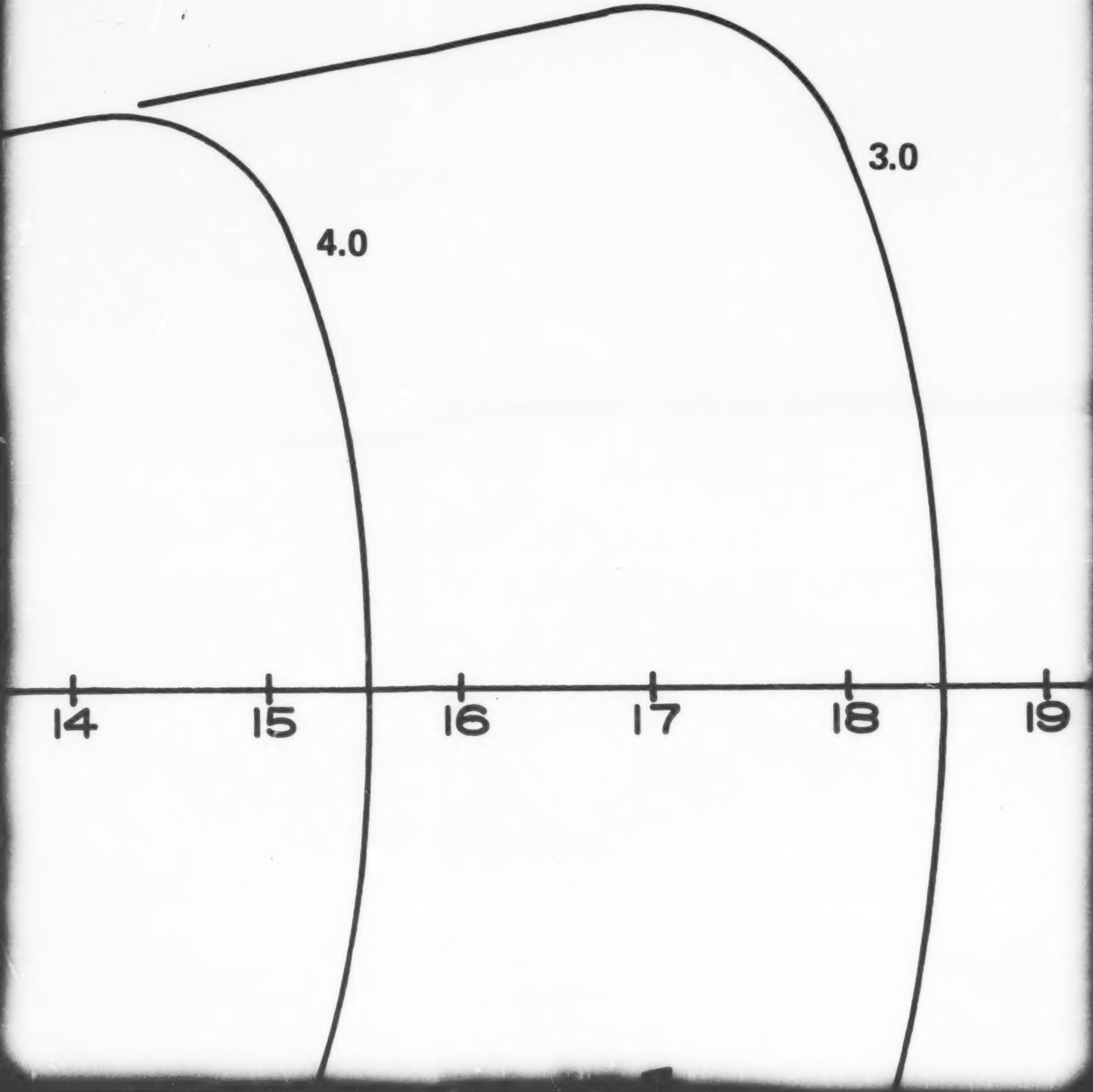

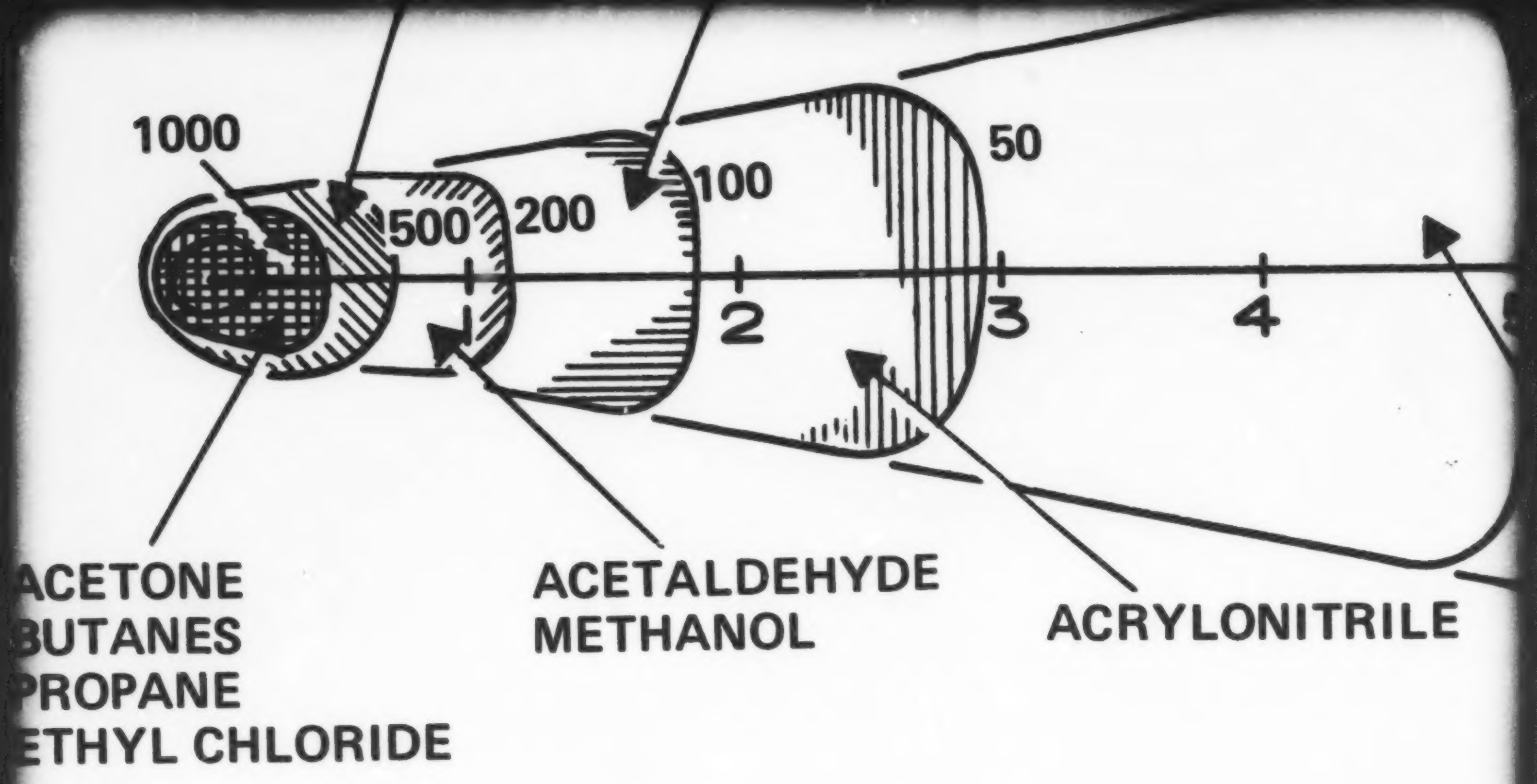
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WIND SPEED = 3 M/SEC.

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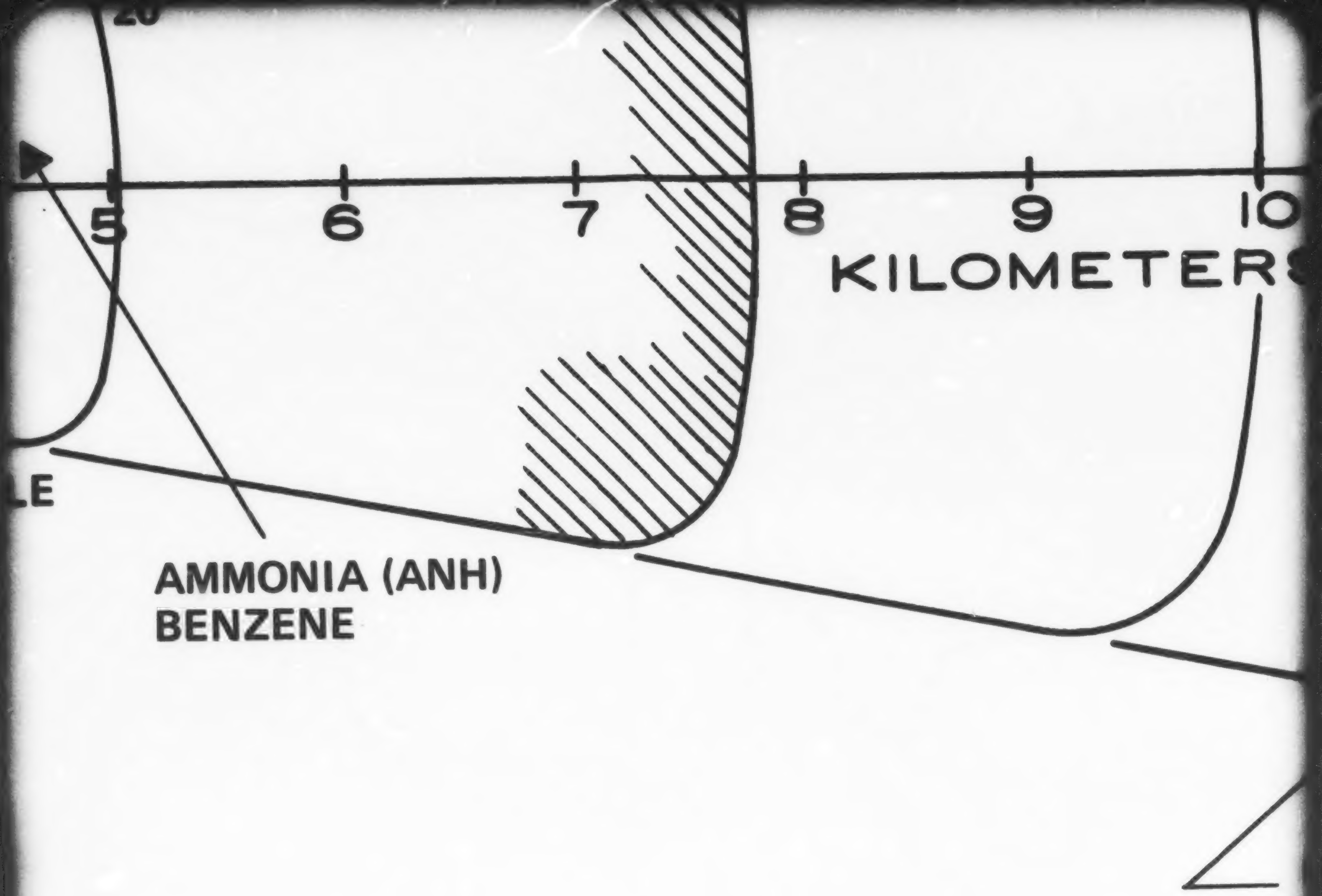
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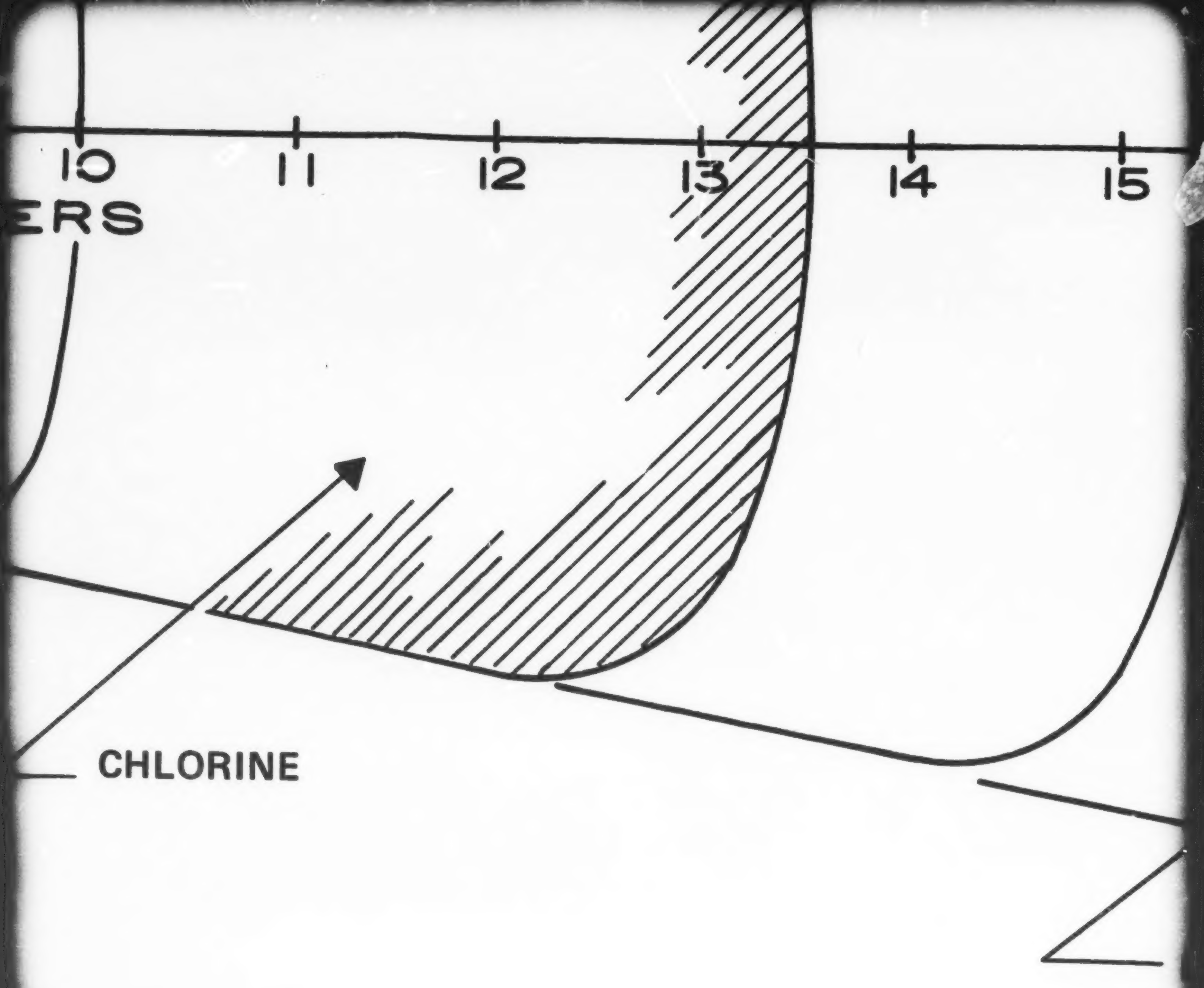

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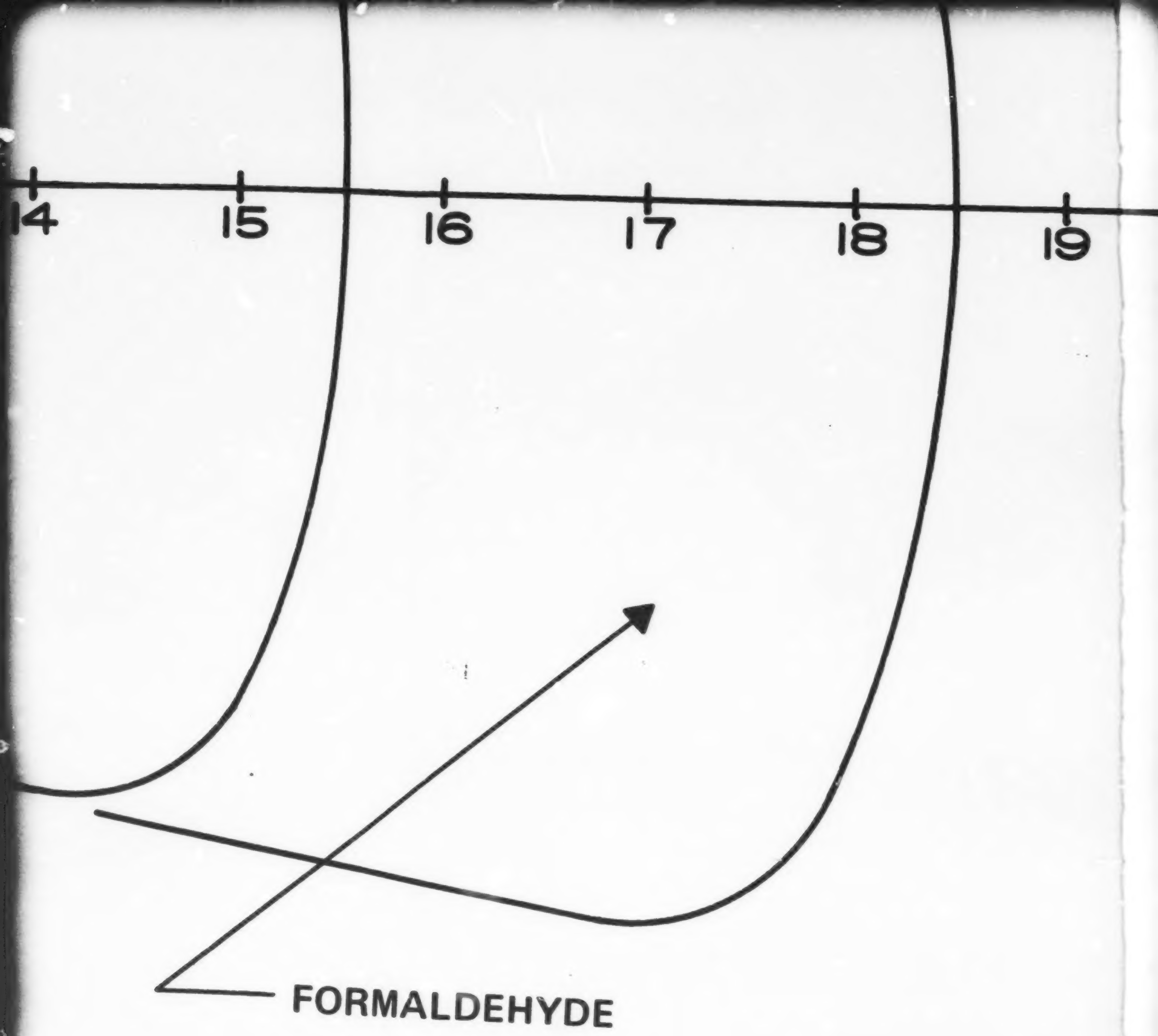

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